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Arakane

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(54) **INKJET PRINTER AND METHOD FOR ACQUIRING GAP INFORMATION OF THE INKJET PRINTER**

(71) Applicant: **Satoru Arakane**, Aichi (JP)

(72) Inventor: **Satoru Arakane**, Aichi (JP)

(73) Assignee: **BROTHER KOGYO KABUSHIKI KAISHA**, Nagoya, Aichi (JP)

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B41J 25/00 (2006.01)
B41J 11/00 (2006.01)

(52) **U.S. Cl.**
CPC ***B41J 25/001*** (2013.01); ***B41J 11/001*** (2013.01); ***B41J 11/005*** (2013.01)

(58) **Field of Classification Search**
CPC B41J 25/308; B41J 29/38; B41J 25/30; B41J 2/165; B41J 23/00; B41J 29/39; B41J 25/001
USPC 347/8
See application file for complete search history.

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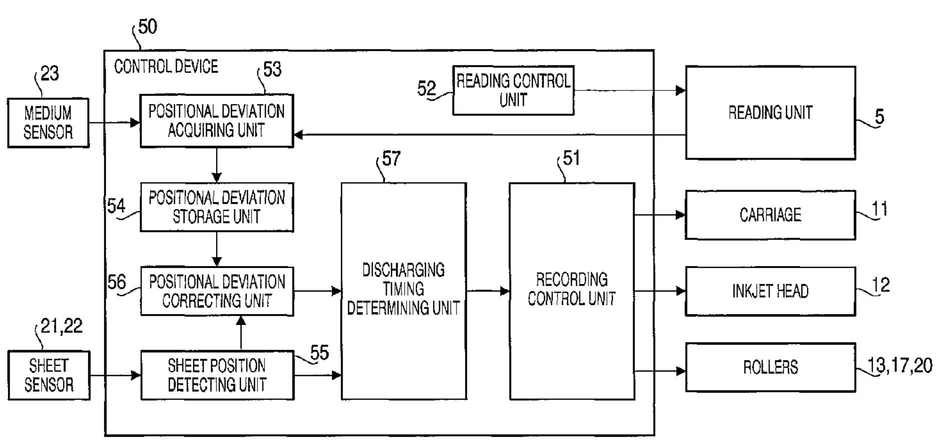
Primary Examiner — Alessandro Amari
Assistant Examiner — Alexander C Witkowski
(74) *Attorney, Agent, or Firm* — Scully, Scott, Murphy & Presser, P.C.

(57) **ABSTRACT**

An inkjet printer, including an inkjet head, a conveyer unit to convey a recording medium in a conveying direction, a position detecting unit to detect a position of the recording medium along the conveying direction, a wave shape generating mechanism to deform the recording medium into a predetermined wave shape along a direction orthogonal to the conveying direction, a gap information storing device to store gap information related to a gap between an ink discharging surface of the inkjet head and the recording medium, and a correcting device to correct the gap information according to a position of the recording medium along the conveying direction, is provided.

17 Claims, 13 Drawing Sheets



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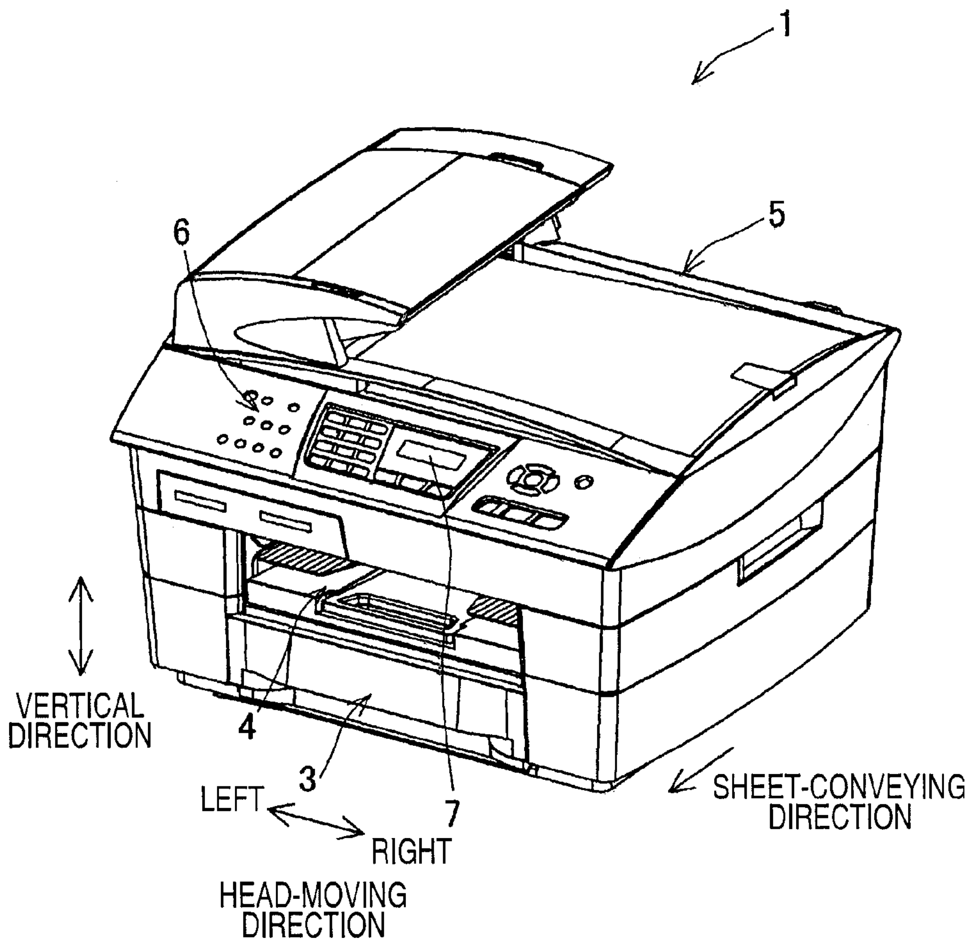

1
5
6
VERTICAL DIRECTION
4
3
7
LEFT
RIGHT
HEAD-MOVING DIRECTION
SHEET-CONVEYING DIRECTION

FIG. 1

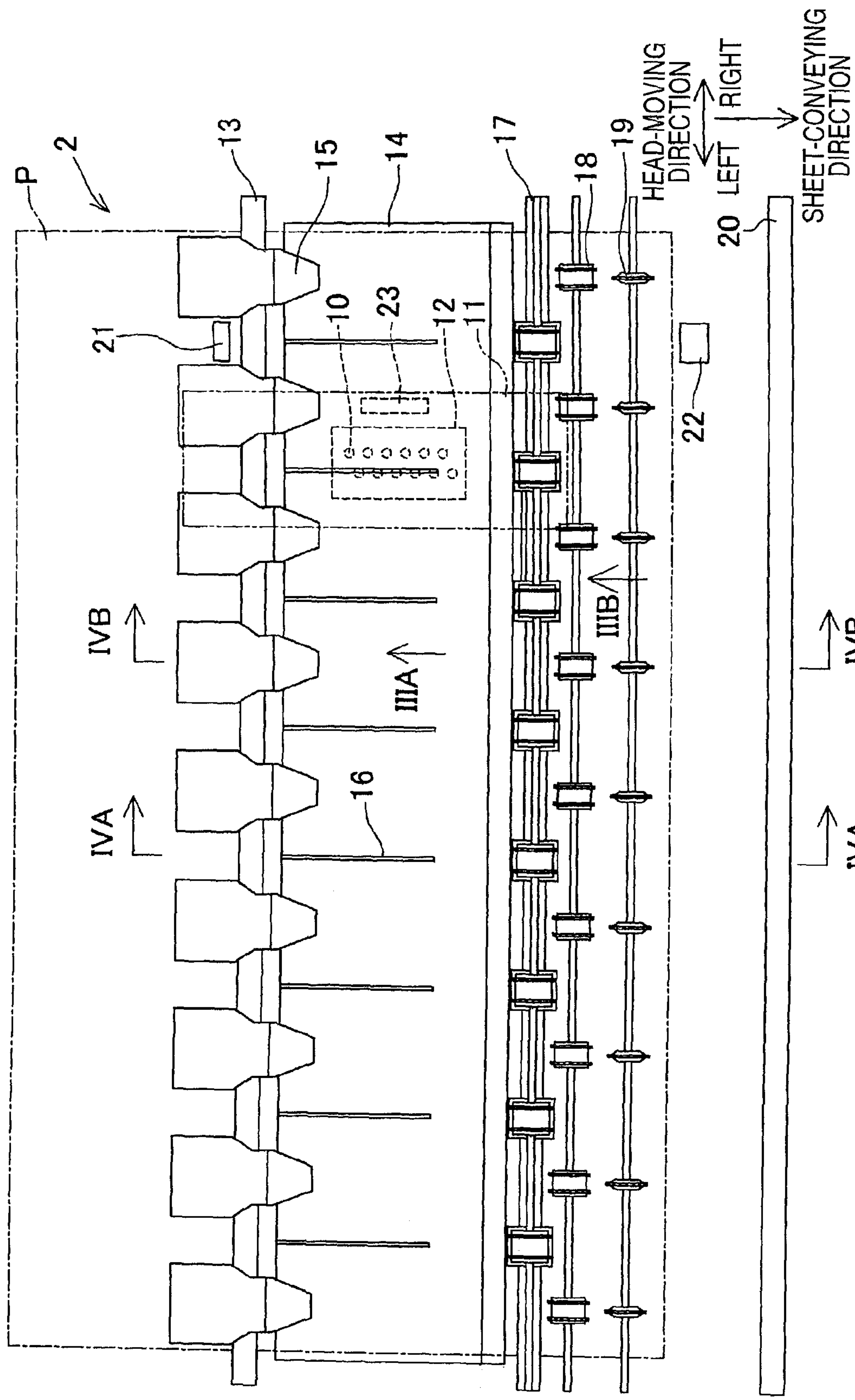
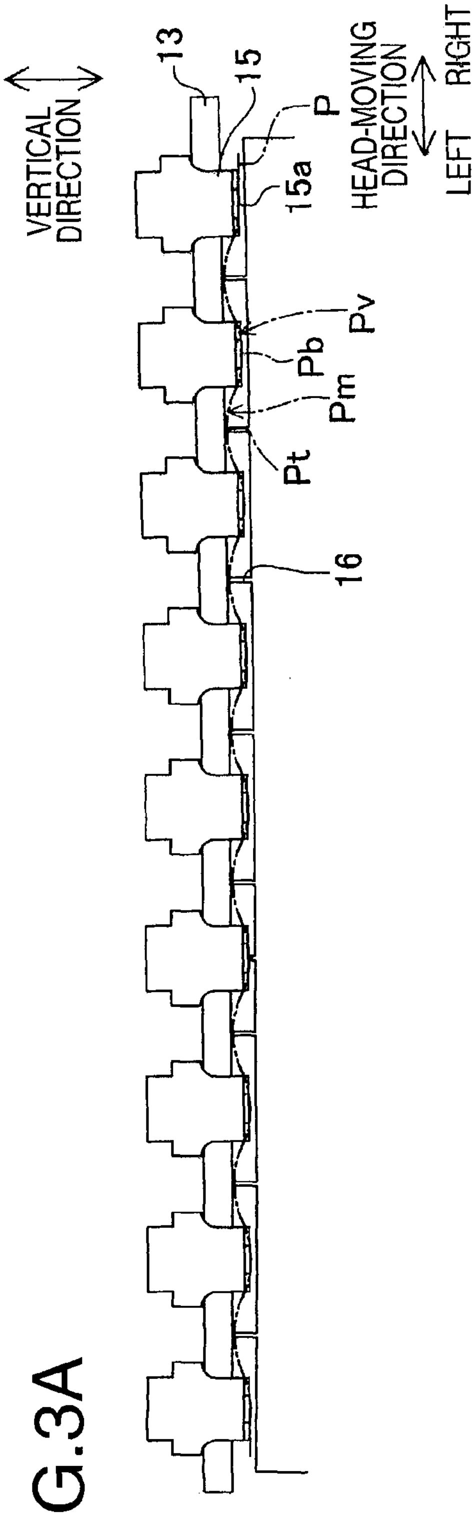

P
2
13
15
14
17
18
19
HEAD-MOVING DIRECTION
LEFT
RIGHT
SHEET-CONVEYING DIRECTION
20
21
10
23
12
11
22
IVB
IIIA
IIIB
IVA
16
IVB
IVA

FIG. 2


VERTICAL DIRECTION
13
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P
15a
HEAD-MOVING DIRECTION
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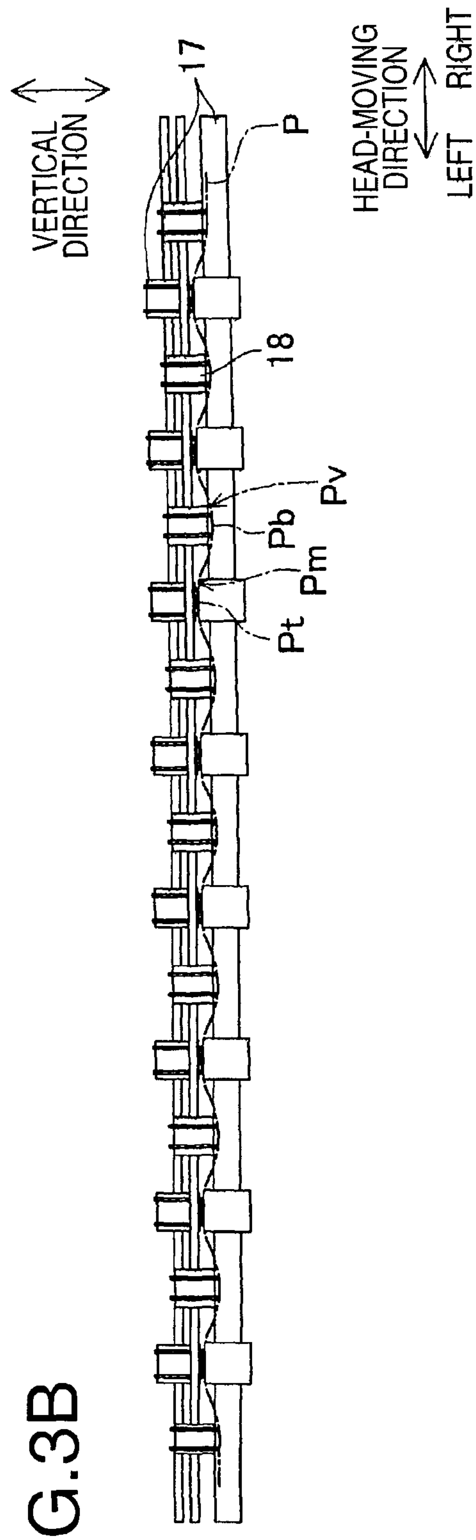
RIGHT
Pv
Pb
Pm
Pt
16

FIG.3A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P
HEAD-MOVING DIRECTION
LEFT
RIGHT
18
Pv
Pb
Pm
Pt

FIG.3B

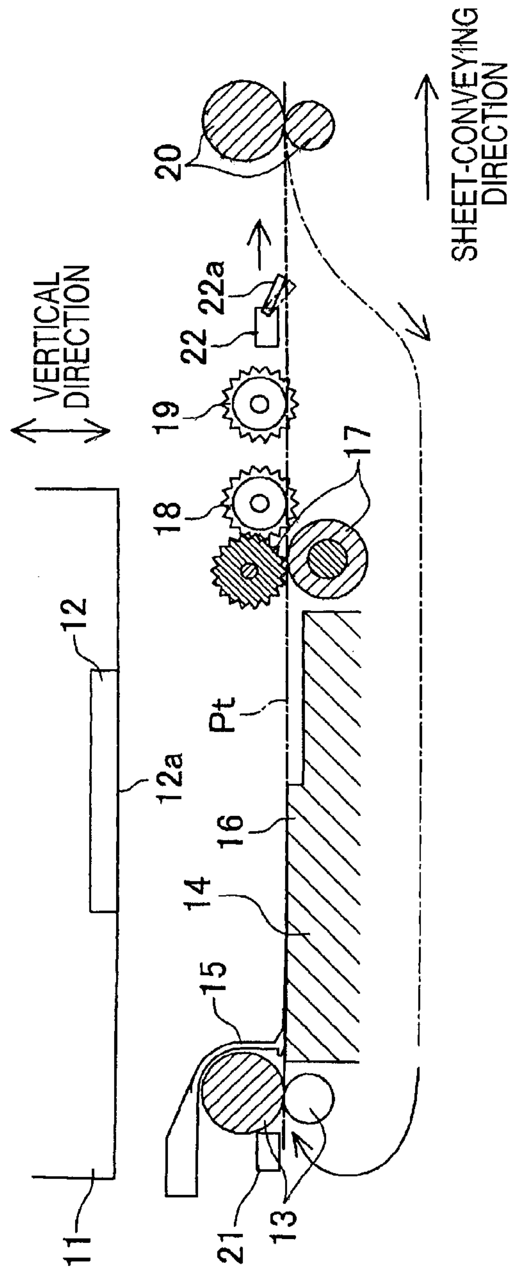

VERTICAL DIRECTION
SHEET-CONVEYING DIRECTION
11
12
12a
13
14
15
16
17
18
19
20
21
22
22a
Pt

FIG.4A

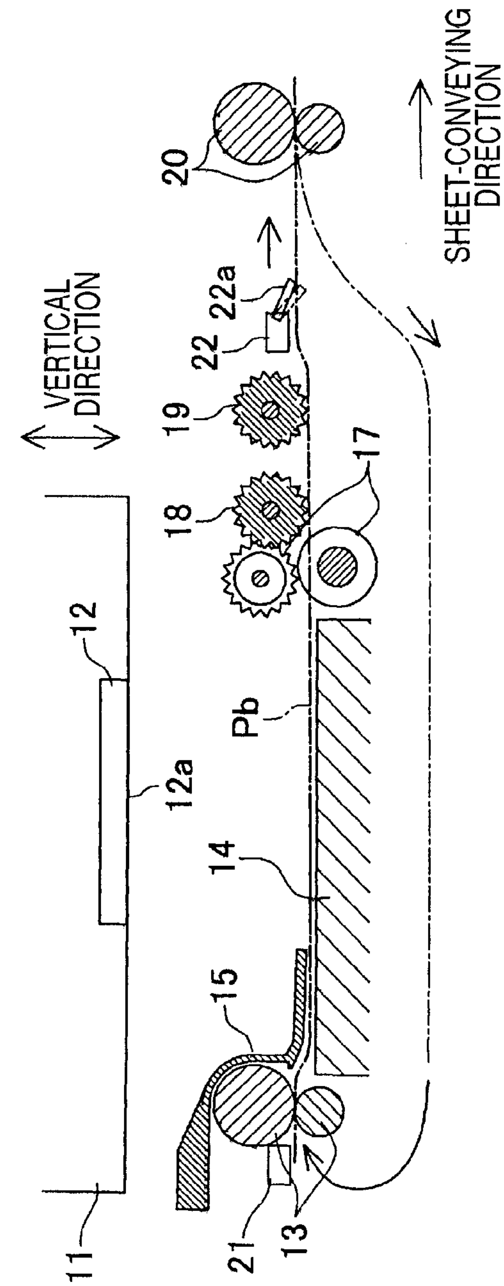
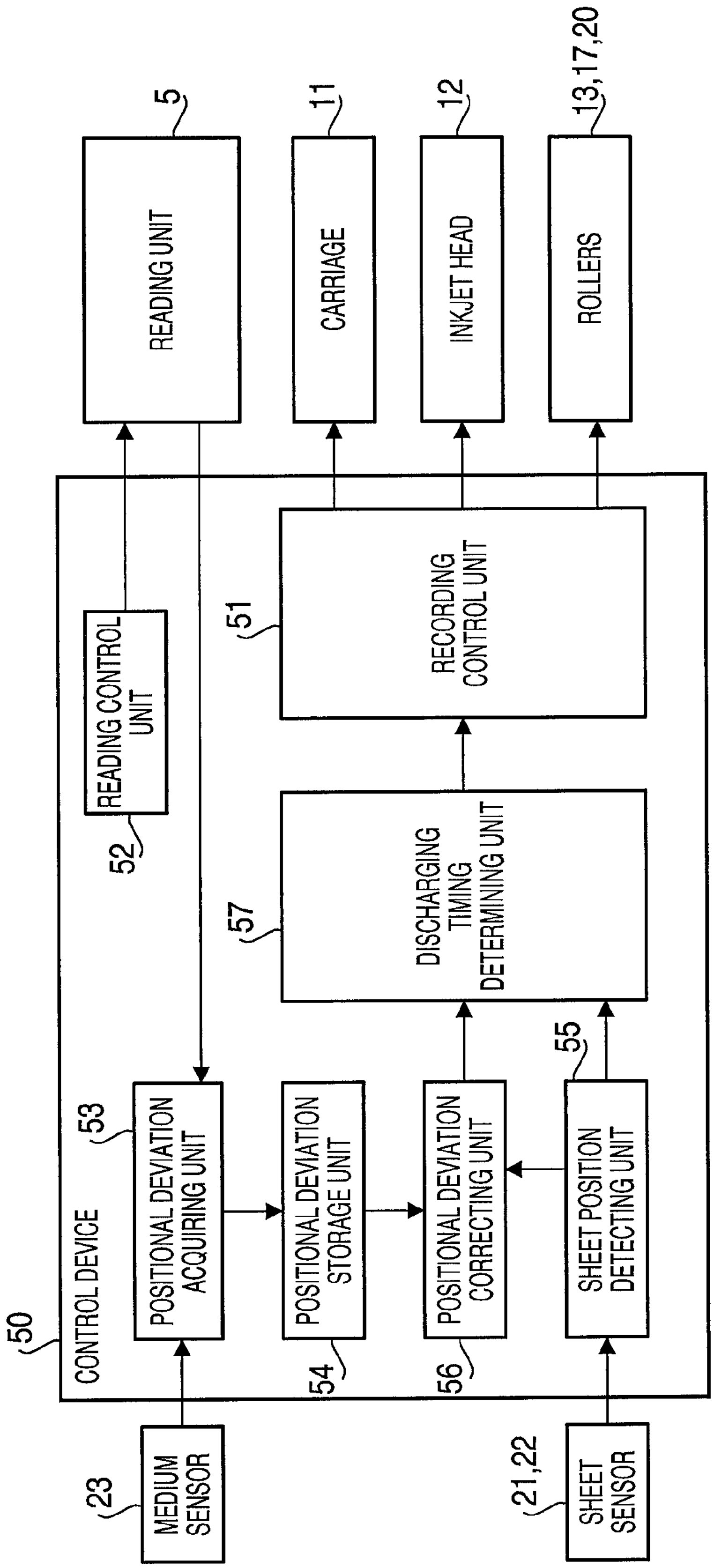

VERTICAL DIRECTION
SHEET-CONVEYING DIRECTION
11
12
12a
13
14
15
17
18
19
20
21
22
22a
Pb

FIG.4B



5
READING UNIT
11
CARRIAGE
12
INKJET HEAD
13,17,20
ROLLERS
50
CONTROL DEVICE
52
READING CONTROL UNIT
51
RECORDING CONTROL UNIT
57
DISCHARGING TIMING DETERMINING UNIT
53
POSITIONAL DEVIATION ACQUIRING UNIT
54
POSITIONAL DEVIATION STORAGE UNIT
56
POSITIONAL DEVIATION CORRECTING UNIT
55
SHEET POSITION DETECTING UNIT
23
MEDIUM SENSOR
21,22
SHEET SENSOR

FIG. 5

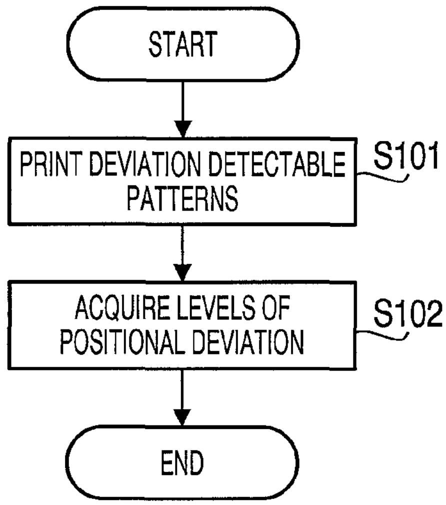

START
PRINT DEVIATION DETECTABLE PATTERNS
S101
ACQUIRE LEVELS OF POSITIONAL DEVIATION
S102
END

FIG.6A

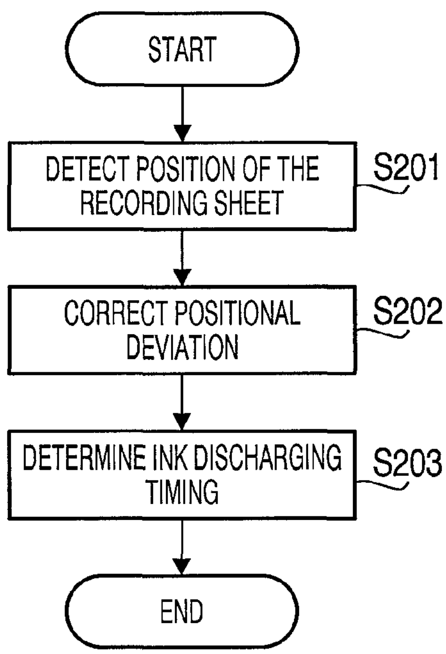

START
DETECT POSITION OF THE RECORDING SHEET
S201
CORRECT POSITIONAL DEVIATION
S202
DETERMINE INK DISCHARGING TIMING
S203
END

FIG.6B

FIG.7A

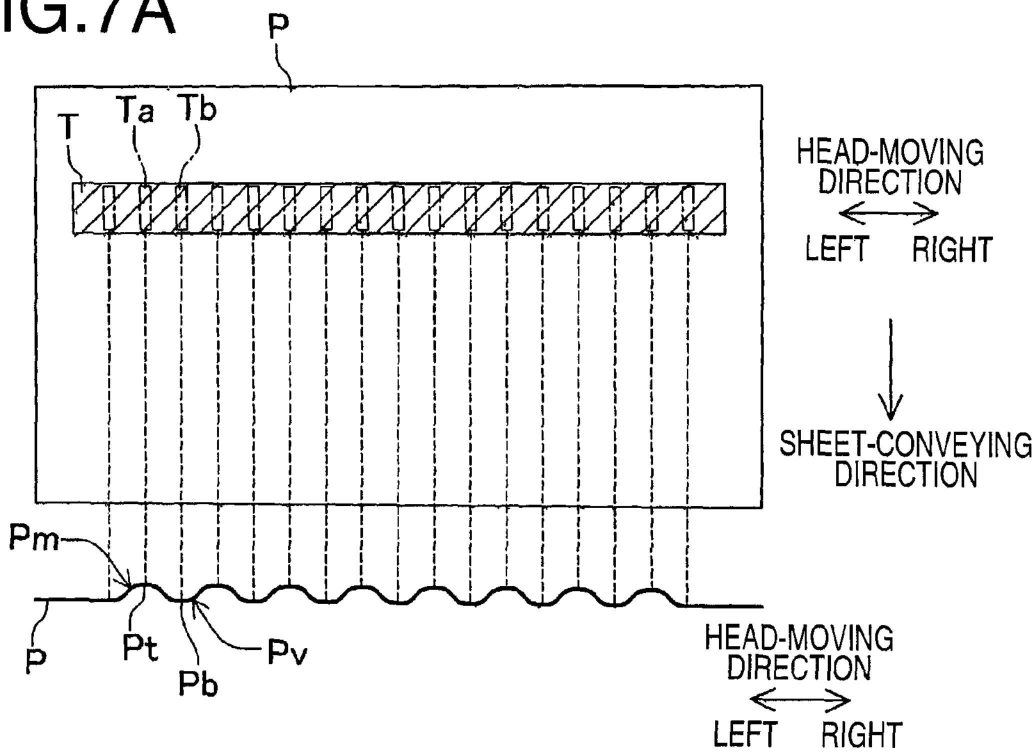

P
T
Ta
Tb
HEAD-MOVING DIRECTION
LEFT
RIGHT
SHEET-CONVEYING DIRECTION
Pm
P
Pt
Pb
Pv
HEAD-MOVING DIRECTION
LEFT
RIGHT

FIG.7B

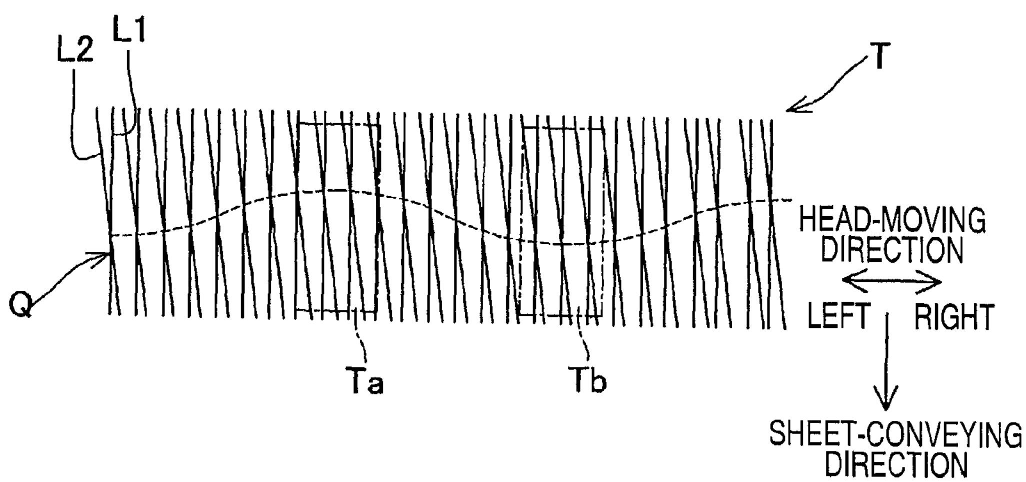

L2
L1
T
Q
HEAD-MOVING DIRECTION
LEFT
RIGHT
Ta
Tb
SHEET-CONVEYING DIRECTION

FIG.8A

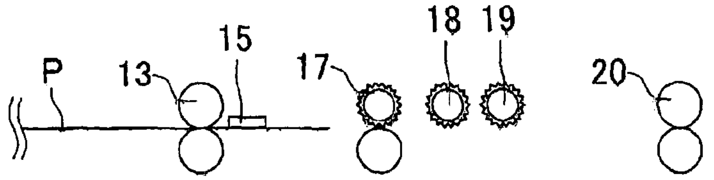


FIG.8B

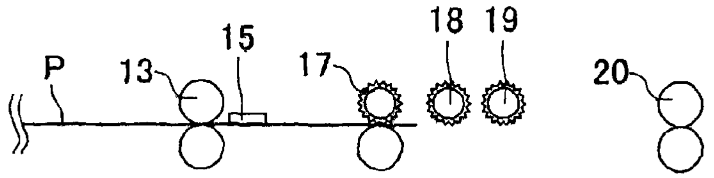


FIG.8C

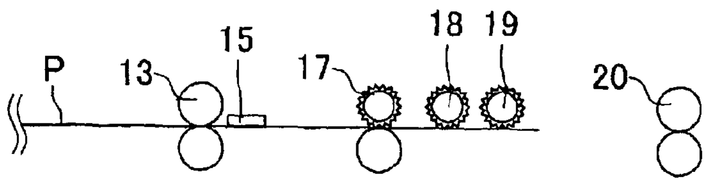


FIG.8D

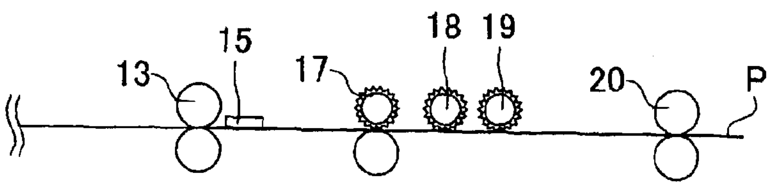


FIG.8E

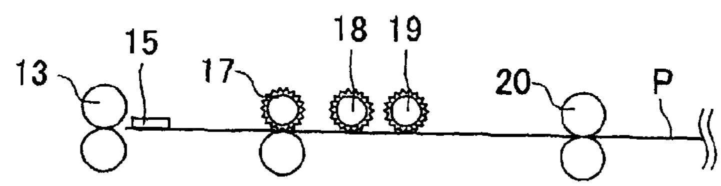


FIG.8F

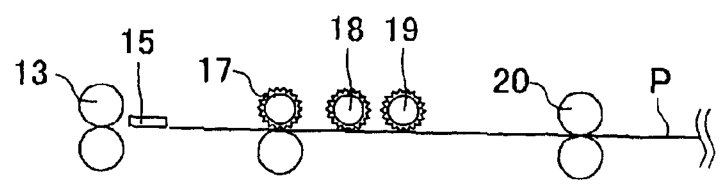


FIG.9A

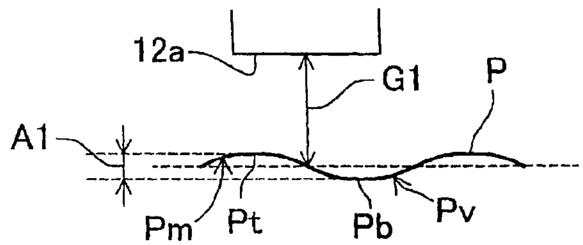


FIG.9B

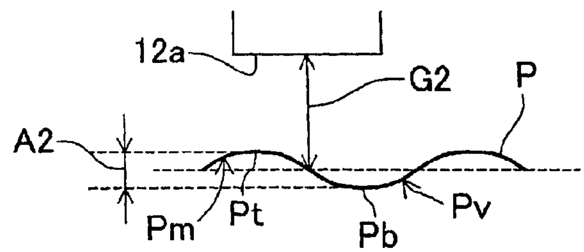


FIG.9C

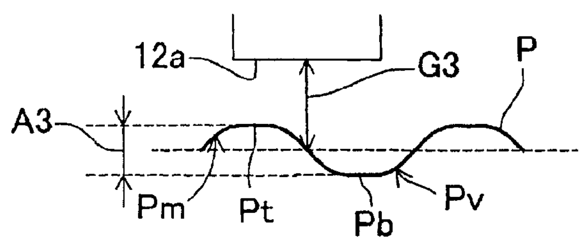


FIG.9D

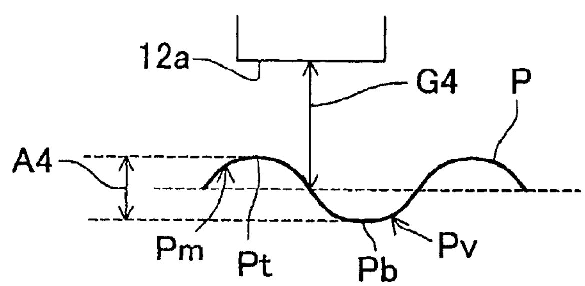
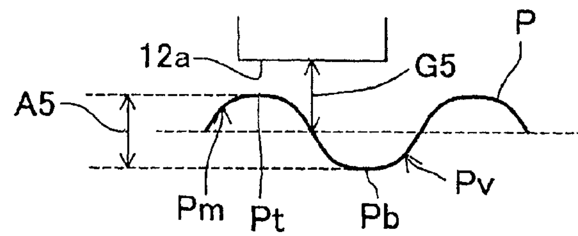
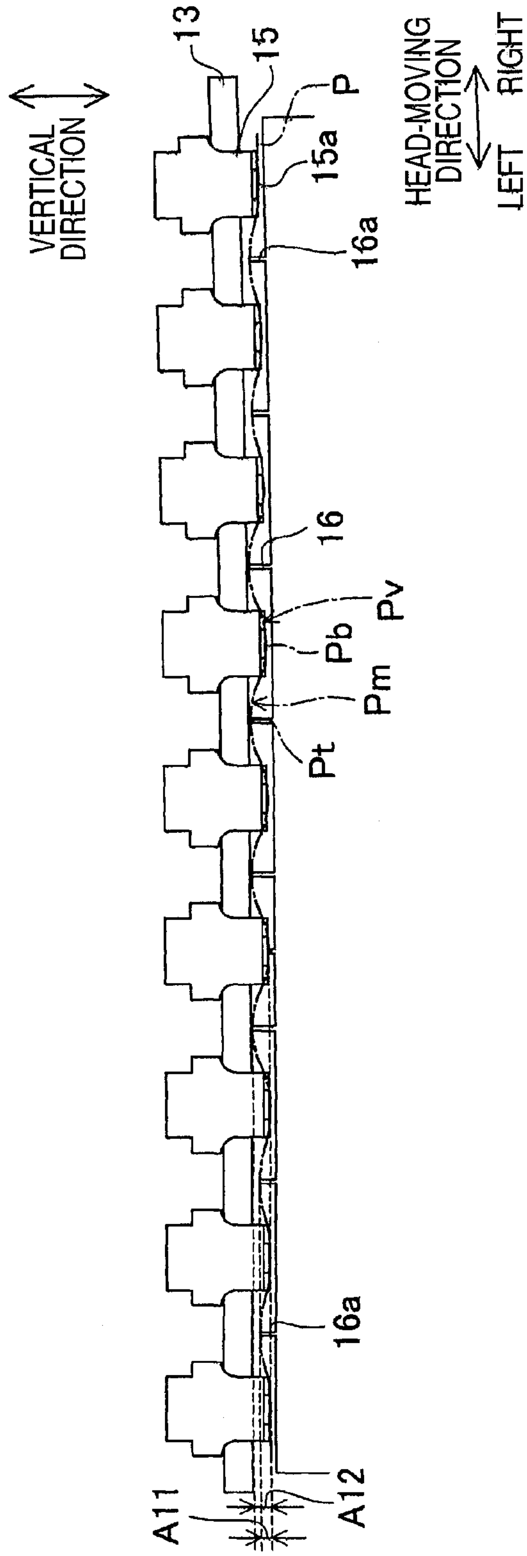


FIG.9E




VERTICAL DIRECTION
13
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P
15a
HEAD-MOVING DIRECTION
LEFT
RIGHT
16a
16
Pv
Pb
Pm
Pt
16a
A11
A12

FIG.10

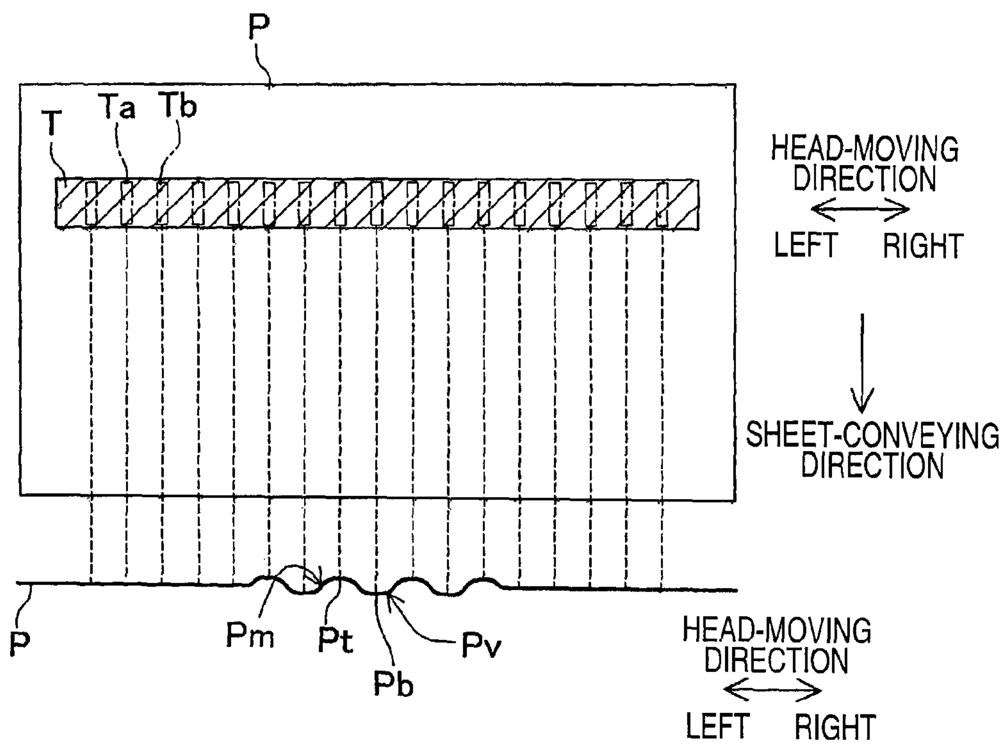

P
T
Ta
Tb
HEAD-MOVING DIRECTION
LEFT
RIGHT
SHEET-CONVEYING DIRECTION
P
Pm
Pt
Pb
Pv
HEAD-MOVING DIRECTION
LEFT
RIGHT

FIG.11

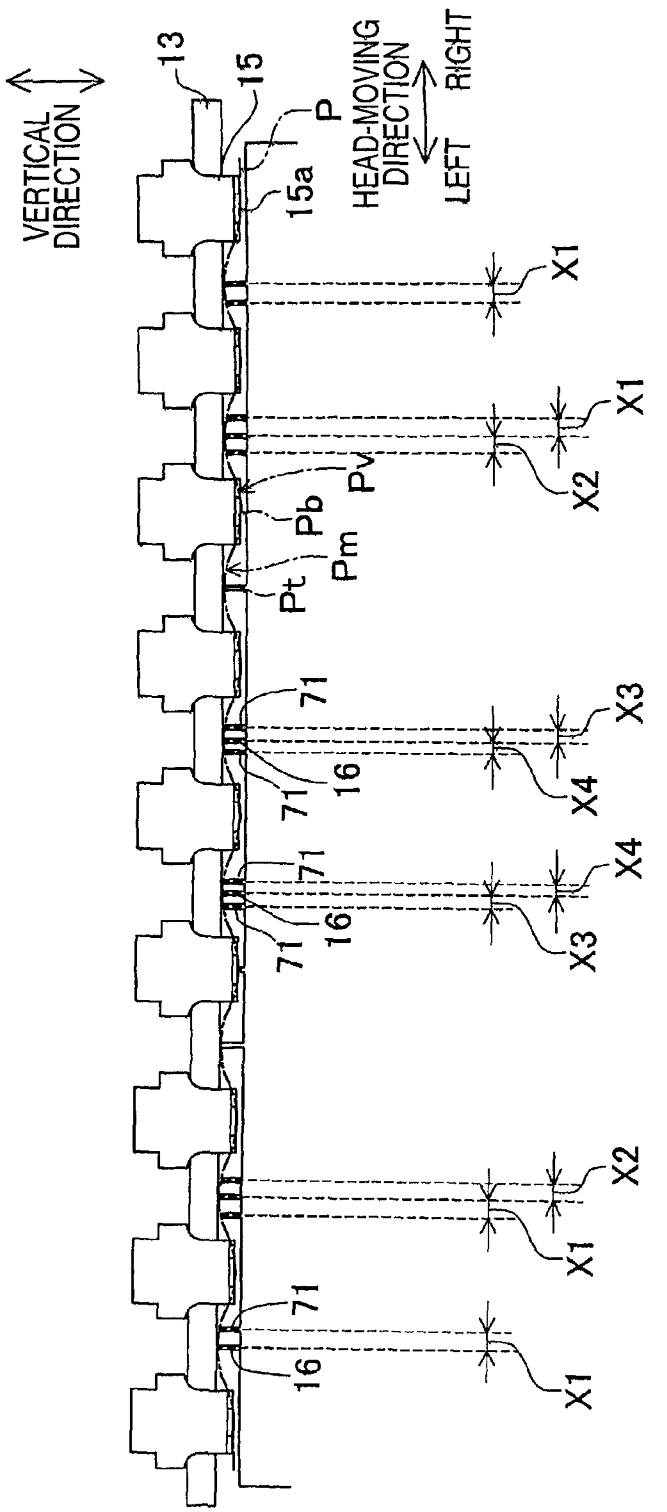

VERTICAL DIRECTION
HEAD-MOVING DIRECTION
LEFT
RIGHT
13
15
15a
P
Pb
Pv
Pt
Pm
71
16
X1
X2
X3
X4

FIG.12

FIG.13A

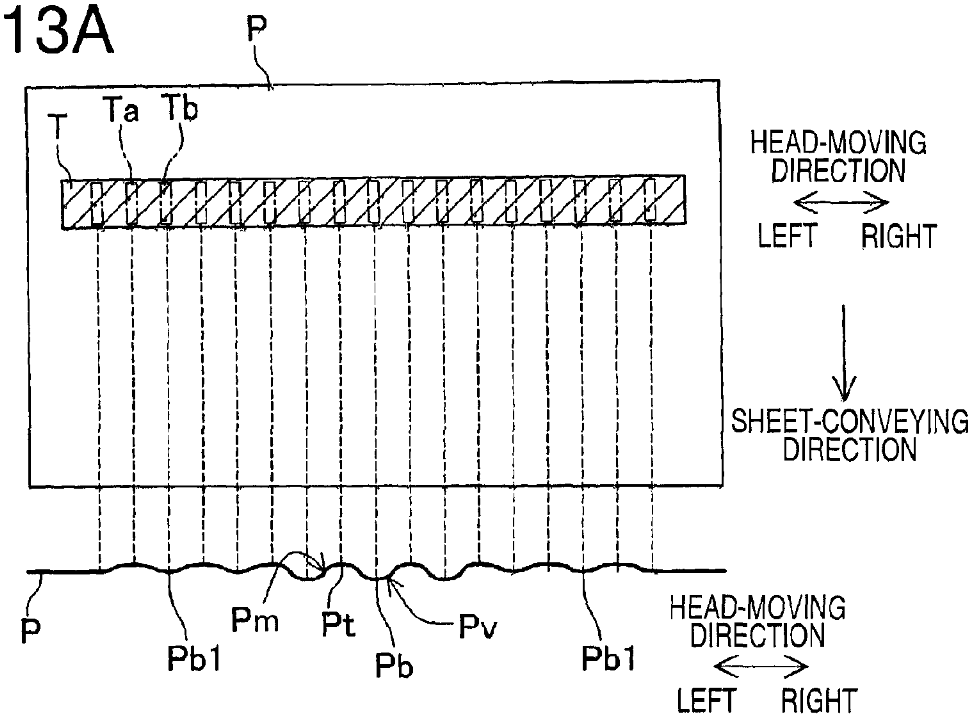
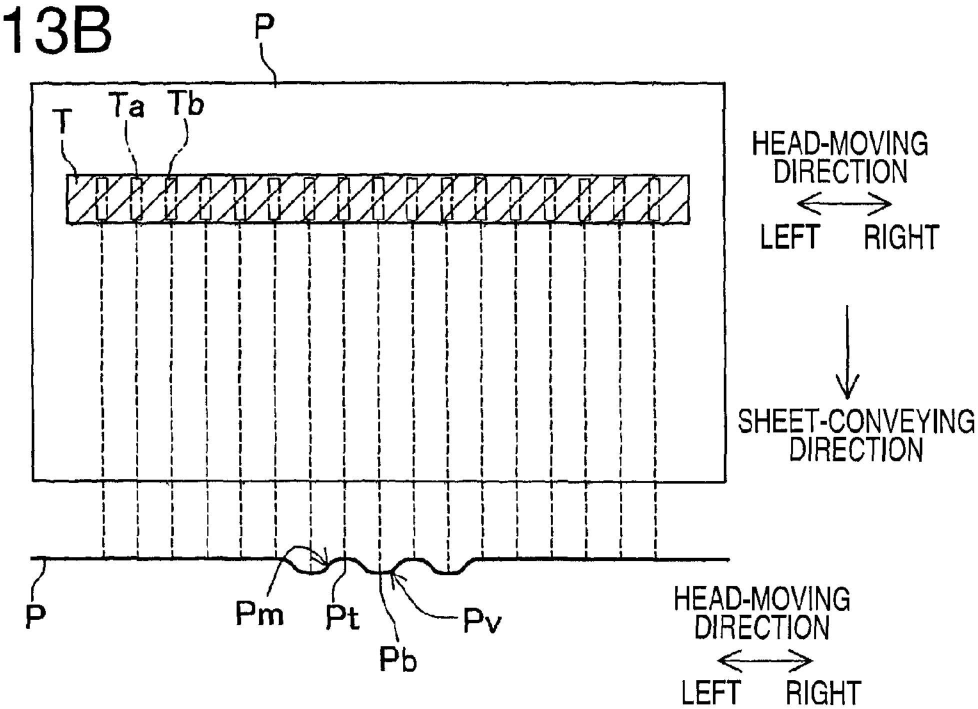


FIG.13B



INKJET PRINTER AND METHOD FOR ACQUIRING GAP INFORMATION OF THE INKJET PRINTER

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2012-082617, filed on Mar. 30, 2012, the entire subject matter of which is incorporated herein by reference.

BACKGROUND

1. Technical Field

The following description relates to one or more techniques for an inkjet printer capable of printing an image on a recording medium by discharging ink from nozzles and a method for acquiring gap information, which is related to a gap between an ink discharging surface of the inkjet printer and the recording medium.

2. Related Art

As an example of inkjet printers configured to perform printing by discharging ink from nozzles onto a recording medium, an inkjet printer has been known that is configured to perform printing by discharging ink onto a recording sheet (a recording medium) from a recording head (an inkjet head) mounted on a carriage reciprocating along a predetermined head-moving direction. Further, the known inkjet printer is configured to cause a feed rollers or corrugated holding spur wheels to press the recording sheet against a surface of a platen that has thereon convex portions and concave portions alternately formed along the head-moving direction, so as to deform the recording sheet in a predetermined wave shape. The predetermined wave shape has mountain portions, which protrude toward an ink discharging surface of the recording head, and valley portions, which are recessed in a direction opposite to the direction toward the ink discharging surface side, alternately arranged along the head-moving direction.

SUMMARY

In the known inkjet printer, levels (amounts) of the gap between the ink discharging surface of the recording head and the recording sheet vary depending on portions (locations) on the recording sheet deformed in the wave shape (hereinafter, which may be referred to as a "wave-shaped recording sheet"). Therefore, when the known inkjet printer performs printing by discharging ink from the recording head onto the wave-shaped recording sheet with the same ink discharging timing as when performing printing on a recording sheet not deformed in such a wave shape, an ink droplet might land in a position deviated from a desired position on the recording sheet. Thus, the positional deviation value with respect to the ink landing position on the recording sheet varies depending on the portions (locations) on the recording sheet.

In view of the above problem, for instance, the following method is considered as a measure for discharging an ink droplet in a desired position on the wave-shaped recording sheet. The method is to adjust ink discharging timing (a moment) to discharge an ink droplet from the inkjet head depending on an amount of the gap between the ink discharging surface of the inkjet head and each individual one of (tops of) the mountain portions and (bottoms of) the valley portions formed on the recording sheet. Further, in order to adjust the ink discharging timing, it is required to detect amounts of the gap between the ink discharging surface of the inkjet head and

each individual one of (the tops of) the mountain portions and (the bottoms of) the valley portions on the recording sheet.

Aspects of the present invention are advantageous in that an inkjet printer, by which information concerning a gap between an ink discharging surface of an inkjet head and each individual one of tops of mountain portions and bottoms of valley portions on a recording sheet deformed in a wave shape can be acquired, and a method to acquire the information are provided.

According to aspects of the present invention, an inkjet printer, including an inkjet head configured to discharge ink droplets from nozzles formed in an ink discharging surface thereof; a head scanning unit configured to move the inkjet head with respect to a recording medium to reciprocate along a head-moving direction, the head-moving direction being parallel with the ink discharging surface of the inkjet head; a conveyer unit configured to convey the recording medium in a conveying direction which intersects the head-moving direction, the conveyer unit including a feed roller and an ejection roller, which are arranged to have the inkjet head interposed therebetween along the conveying direction; a position detecting unit configured to detect a position of the recording medium along the conveying direction; a wave shape generating mechanism configured to deform the recording medium into a predetermined wave shape that has tops of portions protruding toward the ink discharging surface and bottoms of portions recessed toward a side opposite from the ink discharging surface, the tops and the bottoms being alternately arranged along the head-moving direction; a gap information storing device configured to store gap information related to a gap between the ink discharging surface and the recording medium located in a predetermined reference position along the conveying direction, the gap information being acquired from a predetermined range in the recording medium; and a correcting device configured to correct the gap information stored in the gap information storing device according to a position of the recording medium along the conveying direction detected by the position detecting unit, is provided.

According to aspects of the present invention, a method configured to be implemented on a control device connected with an inkjet printer is provided. The inkjet printer includes an inkjet head configured to discharge ink droplets from nozzles formed in an ink discharging surface thereof; a conveyer unit configured to convey a recording medium in a conveying direction, the conveyer unit including a feed roller and an ejection roller, which are arranged to have the inkjet head interposed therebetween along the conveying direction; a position detecting unit configured to detect a position of the recording medium along the conveying direction; a wave shape generating mechanism configured to deform the recording medium into a predetermined wave shape that has tops of portions protruding toward the ink discharging surface and bottoms of portions recessed toward a side opposite from the ink discharging surface, the tops and the bottoms being alternately arranged along an orthogonal direction being orthogonal to the conveying direction; and a control device. The control device is configured to store gap information related to a gap between the ink discharging surface and the recording medium located in a predetermined reference position along the conveying direction, the gap information being acquired from a predetermined range in the recording medium; and correct the stored gap information according to a position of the recording medium along the conveying direction detected by the position detecting unit.

According to aspects of the present invention, an inkjet printer including an inkjet head configured to discharge ink droplets from nozzles formed in an ink discharging surface thereof; a head scanning unit configured to move the inkjet head with respect to a recording medium to reciprocate along a head-moving direction, the head-moving direction being parallel with the ink discharging surface of the inkjet head; a conveyer unit configured to convey the recording medium in a conveying direction which intersects the head-moving direction, the conveyer unit including a feed roller and an ejection roller, which are arranged to have the inkjet head interposed therebetween along the conveying direction; a position detecting unit configured to detect a position of the recording medium along the conveying direction; a wave shape generating mechanism configured to deform the recording medium into a predetermined wave shape that has tops of portions protruding toward the ink discharging surface and bottoms of portions recessed toward a side opposite from the ink discharging surface, the tops and the bottoms being alternately arranged along the head-moving direction; and a control device is provided. The control device is configured to store gap information related to a gap between the ink discharging surface and the recording medium located in a predetermined reference position along the conveying direction, the gap information being acquired from a predetermined range in the recording medium; and correct the stored gap information according to a position of the recording medium along the conveying direction detected by the position detecting unit.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

FIG. **1** is a perspective view schematically showing a configuration of an inkjet printer in an embodiment according to one or more aspects of the present invention.

FIG. **2** is a top view of a printing unit of the inkjet printer in the embodiment according to one or more aspects of the present invention.

FIG. **3**A schematically shows a part of the printing unit when viewed along an arrow IIIA shown in FIG. **2** in the embodiment according to one or more aspects of the present invention.

FIG. **3**B schematically shows a part of the printing unit when viewed along an arrow IIIB shown in FIG. **2** in the embodiment according to one or more aspects of the present invention.

FIG. **4**A is a cross-sectional view taken along a line IVA-IVA shown in FIG. **2** in the embodiment according to one or more aspects of the present invention.

FIG. **4**B is a cross-sectional view taken along a line IVB-IVB shown in FIG. **2** in the embodiment according to one or more aspects of the present invention.

FIG. **5** is a functional block diagram of a control device of the inkjet printer in the embodiment according to one or more aspects of the present invention.

FIG. **6**A is a flowchart to illustrate a process, which is to be executed prior to a printing operation, to determine ink discharging timing to discharge ink from nozzles in the inkjet printer in the embodiment according to one or more aspects of the present invention.

FIG. **6**B is a flowchart to illustrate a process, which is to be executed during a printing operation, to determine ink discharging timing to discharge ink from nozzles in the inkjet printer in the embodiment according to one or more aspects of the present invention.

FIG. **7**A shows deviation detectable patterns printed on a recording sheet and positions to read the deviation detectable patterns in the embodiment according to one or more aspects of the present invention.

FIG. **7**B is an enlarged view partially showing a part including a plurality of deviation detectable patterns printed on the recording sheet in the embodiment according to one or more aspects of the present invention.

FIGS. **8**A-**8**F illustrate transition of positions of the recording sheet being conveyed along a sheet-conveying direction in the inkjet printer in the embodiment according to one or more aspects of the present invention.

FIGS. **9**A-**9**E illustrate amplitudes in ripples in the recording sheet in a wave shape and fluctuation of amounts of a gap between an ink discharging surface and the recording sheet in the inkjet printer in the conditions illustrated in FIGS. **8**A-**8**F in the embodiment according to one or more aspects of the present invention.

FIG. **10** is a first modified example of the part of the printing unit when viewed along the arrow IIIA shown in FIG. **2** in the embodiment according to one or more aspects of the present invention.

FIG. **11** illustrates a condition of the recording sheet in the first modified example when the recording sheet being conveyed along the sheet-conveying direction in the inkjet printer reaches a position illustrated in FIG. **8**F in the embodiment according to one or more aspects of the present invention.

FIG. **12** is a second modified example of the part of the printing unit when viewed along the arrow IIIA shown in FIG. **2** in the embodiment according to one or more aspects of the present invention.

FIGS. **13**A and **13**B illustrates conditions of the recording sheet in the second modified example when the recording sheet being conveyed along the sheet-conveying direction in the inkjet printer reaches a position illustrated in FIG. **8**F in the embodiment according to one or more aspects of the present invention.

DETAILED DESCRIPTION

It is noted that various connections are set forth between elements in the following description. It is noted that these connections in general and, unless specified otherwise, may be direct or indirect and that this specification is not intended to be limiting in this respect. Aspects of the invention may be implemented in computer software as programs storable on computer readable media including but not limited to RAMs, ROMs, flash memories, EEPROMs, CD-media, DVD-media, temporary storage, hard disk drives, floppy drives, permanent storage, and the like.

Hereinafter, embodiments according to aspects of the present invention will be described in detail with reference to the accompanying drawings.

An inkjet printer **1** of the embodiment is a multi-function peripheral having a plurality of functions such as a printing function to perform printing on a recording sheet P and an image reading function. The inkjet printer **1** includes a printing unit **2** (see FIG. **2**), a sheet feeding unit **3**, a sheet ejecting unit **4**, a reading unit **5**, an operation unit **6**, and a display unit **7**. Further, the inkjet printer **1** includes a control device **50** configured to control operations of the inkjet printer **1** (see FIG. **5**).

The printing unit **2** is provided inside the inkjet printer **1**. The printing unit **2** is configured to perform printing on the recording sheet P. A detailed configuration of the printing unit **2** will be described later. The sheet feeding unit **3** is configured to feed the recording sheet P to be printed by the printing unit **2**. The sheet ejecting unit **4** is configured to eject the recording sheet P printed by the printing unit **2**. The reading unit **5** is configured to be, for instance, an image scanner for reading images such as below-mentioned deviation detectable patterns for detecting displacement of ink droplets landing on the recording sheet P. The operation unit **6** is provided with buttons. A user is allowed to operate the inkjet printer **1** via the buttons of the operation unit **6**. The display unit **7** is configured, for instance, as a liquid crystal display, to display information when the inkjet printer **1** is used.

Subsequently, the printing unit **2** will be described. As shown in FIGS. **2** to **4**, the printing unit **2** includes a carriage **11**, an inkjet head **12**, a feed roller **13**, a platen **14**, a plurality of corrugated plates **15**, a plurality of ribs **16**, an ejection roller **17**, and a plurality of corrugated spur wheels **18**, **19**, a switchback roller **20**, sheet sensors **21**, **22**, and a medium sensor **23**. It is noted that, for the sake of easy visual understanding in FIG. **2**, the carriage **11** is indicated by a dash-and-two-dots line, and portions disposed below the carriage **11** are indicated by solid lines.

The carriage **11** is configured to reciprocate on a guiderail (not shown) along a predetermined head-moving direction. The inkjet head **12** is mounted on the carriage **11** to be driven along with the carriage **11**. The inkjet head **12** is configured to discharge ink from a plurality of nozzles **10** formed in an ink discharging surface **12***a* that is a lower surface of the inkjet head **12**. It is noted that, the inkjet head **12** may be a line head extending over a whole length of a printable area in the head-moving direction. In this case, a head scanning mechanism such as the carriage **11** may not be provided, and a longitudinal (extending) direction of the line head may replace the head-moving direction.

The feed roller **13** includes two rollers configured to nip therebetween the recording sheet P fed by the sheet feeding unit **3** and feed the recording sheet P in a predetermined sheet-conveying direction, which is orthogonal to the head-moving direction. The platen **14** is disposed to face the ink discharging surface **12***a*. The recording sheet P is fed by the feed rollers **13**, along an upper surface of the platen **14**.

The plurality of corrugated plates **15** are disposed to face an upper surface of an upstream end of the platen **14** along the sheet-conveying direction. The plurality of corrugated plates **15** are arranged at substantially even intervals along the head-moving direction. The recording sheet P, fed by the feed rollers **13**, passes between the platen **14** and the corrugated plates **15**. At this time, pressing surfaces **15***a*, which are lower surfaces of the plurality of corrugated plates **15**, press the recording sheet P from above.

Each of the plurality of ribs **16** is disposed between a corresponding two of mutually adjacent corrugated plates **15** along the head-moving direction, on the upper surface of the platen **14**. The plurality of ribs **16** are arranged at substantially even intervals along the head-moving direction. Each rib **16** protrudes from the upper surface of the platen **14** up to a level higher than the pressing surfaces **15***a* of the corrugated plates **15**. Each rib **16** extends from an upstream end of the platen **14** toward a downstream side along the sheet-conveying direction. Thereby, the recording sheet P on the platen **14** is supported from underneath by the plurality of ribs **16**.

The ejection roller **17** includes two rollers configured to nip therebetween portions of the recording sheet P that are located in the same positions as the plurality of ribs **16** along the head-moving direction and feed the recording sheet P toward the sheet ejecting unit **4**. An upper one of the ejection rollers **17** is provided with spur wheels so as to prevent the ink attached onto the recording sheet P from being transferred to the upper ejection roller **17**.

The plurality of corrugated spur wheels **18** are disposed substantially in the same positions as the corrugated plates **15** along the head-moving direction, at a downstream side relative to the ejection rollers **17** along the sheet-conveying direction. The plurality of corrugated spur wheels **19** are disposed substantially in the same positions as the corrugated plates **15** along the head-moving direction, at a downstream side relative to the corrugated spur wheels **18** in the sheet-conveying direction. In addition, the plurality of corrugated spur wheels **18** and **19** are placed at a level lower than a position where the ejection rollers **17** nip the recording sheet P therebetween, along the vertical direction. The plurality of corrugated spur wheels **18** and **19** are configured to press the recording sheet P from above at the level. Further, the plurality of corrugated spur wheels **18** and **19** are not rollers having a smooth outer circumferential surface but a spur wheel. Therefore, it is possible to prevent the ink attached onto the recording sheet P from being transferred to the plurality of corrugated spur wheels **18** and **19**.

Thus, the recording sheet P on the platen **14** is pressed from above by the plurality of corrugated plates **15** and the plurality of corrugated spur wheels **18** and **19**, and is supported from below by the plurality of ribs **16**. Thereby, as shown in FIG. **3**, the recording sheet P on the platen **14** is bent and deformed in such a wave shape that mountain portions Pm protruding upward (i.e., toward the ink discharging surface **12***a*) and valley portions Pv recessed downward (i.e., in a direction opposite to the direction toward the ink discharging surface **12***a*) are alternately arranged along the head-moving direction. Further, each mountain portion Pm has a top portion Pt, protruding up to the highest position of the mountain portion Pm, which is located substantially in the same position as the center of the corresponding rib **16** in the head-moving direction. Each valley portion Pv has a bottom portion Pb, recessed down to the lowest position of the valley portion Pv, which is located substantially in the same position as the corresponding corrugated plates **15** and the corresponding corrugated spur wheels **18** and **19**.

The switchback roller **20** includes two rollers, which are arranged on the downstream side relative to the corrugated spur wheels **19** in the sheet-conveying direction. If images are to be printed on both sides of the recording sheet P in a double-face printing operation, and when the recording sheet P with the image having been formed on one of the two sides is conveyed to the switchback rollers **20**, the switchback rollers **20** provide a switchback mechanism to convey the recording sheet P underneath the platen **14** and direct to an upstream side with respect to the feed rollers **13** once again. Further, when the printing operation to the recording sheet P is completed, the switchback rollers **20**, along with the ejection rollers **17**, convey the recording sheet P having been through the printing operation toward the downstream side along the sheet-conveying direction to the sheet ejection unit **4**. The switchback mechanism, other than the switchback rollers **20** in the present embodiment, may be in a known configuration. Therefore, detailed explanation of the switchback mechanism is herein omitted.

The sheet sensor **21** is arranged on an upstream side with respect to the feed rollers **13** along the sheet-conveying direction and is configured to detect presence or absence of the recording sheet P. The sheet sensor **21** may be, for example, an optical sensor. The sheet sensor **22**, on the other hand, is arranged on a downstream side with respect to the corrugated spur wheel **19** along the sheet-conveying direction. The sheet sensor **22** in the present embodiment includes a lever **22***a*. The lever **22***a* is arranged to have a tip end thereof in a position, through which the recording sheet P being conveyed by the ejection rollers **17** passes. Therefore, when the recording sheet P conveyed by the ejection rollers **17** reaches the tip end of the lever **22***a*, the lever **22***a* is uplifted by the recording sheet P being conveyed. Thus, presence of the recording sheet P is detected via the uplifted movement of the lever **22***a*. When the uplifted movement is not sensed, it is determined that no recording sheet P is present at the position of the sheet sensor **22**.

The medium sensor **23** is mounted on the carriage **11** and is configured to detect whether there is a recording sheet P on the platen **14**. Specifically, for instance, the medium sensor **20** includes a light emitting element and a light receiving element. The medium sensor **20** emits light from the light emitting element toward the upper surface of the platen **14**. The upper surface of the platen **14** is black. Therefore, when there is no recording sheet P on the platen **14**, the light emitted from the light emitting element is not reflected by the upper surface of the platen **14** or received by the light receiving element. Meanwhile, when there is a recording sheet P on the platen **14**, the light emitted from the light emitting element is reflected by the recording sheet P and received by the light receiving element. Thus, the medium sensor **20** detects presence of the recording sheet P on the platen **14**, based on whether the light receiving element receives the light emitted from the light emitting element.

The printing unit **2** configured as above performs printing on the recording sheet P by discharging ink from the inkjet head **12** reciprocating together with the carriage **11** along the head-moving direction, while conveying the recording sheet P in the sheet-conveying direction by the feed rollers **13**, the ejection rollers **17**, and the switchback rollers **20**. The ejection rollers **17** and the feed rollers **13** are arranged in positions to have the inkjet head **12** interposed therebetween along the sheet-conveying direction.

Next, an explanation will be provided about the control device **50** for controlling the operations of the inkjet printer **1**. The control device **50** includes a central processing unit (CPU), a read only memory (ROM), a random access memory (RAM), and control circuits. The control device **50** is configured to function as various elements such as a recording control unit **51**, a reading control unit **52**, a positional deviation acquiring unit **53**, a positional deviation storage unit **54**, a sheet position detecting unit **55**, a positional deviation correcting unit **56**, and a discharging timing determining unit **57** (see FIG. **5**).

The recording control unit **51** controls behaviors of the carriage **11**, the inkjet head **12**, the feed rollers **13**, the ejection rollers **17**, and the switchback rollers **20** when images including deviation detectable patterns Q, which will be described later in detail, are printed. The reading controller **52** controls behaviors of the reading unit **5** when images, including the deviation detectable patterns Q, appearing on a recording sheet is read. The positional deviation acquiring unit **53** acquires amounts of positional deviation of ink droplets landing on the top portions Pt and the bottom portions Pb of the recording sheet P, from the below-mentioned deviation detectable patterns Q read by the reading unit **5**. It is noted that the amounts of positional deviation detected based on the deviation detectable patterns Q may be referred to as "gap information," which is information related to a gap between the ink discharging surface **12***a* and each of the top portions Pt and the bottom portions Pb. The positional deviation storage unit **54** stores the amounts of positional deviation detected from the deviation detectable patterns Q, i.e., the gap information, acquired by the positional deviation acquiring unit **53**.

The sheet position detecting unit **55** is configured to detect a position of the recording sheet P being conveyed during a printing operation. More specifically, a position of a leading edge of the recording sheet P being conveyed is detected in consideration of a conveying capacity of the feed rollers **13** and the ejection rollers **17** and a time period starting from detection of presence of the recording sheet P by the sheet sensor **21**. Further, a position of a rear edge of the recording sheet P being conveyed is detected in consideration of the conveying capacity of the feed rollers **13** and the ejection rollers **17**, and a time period starting from detection of absence of the recording sheet P by the sheet sensor **21**.

Further, the sheet position detecting unit **55** is configured to detect that the recording sheet P is conveyed without experiencing an error to the downstream side with respect to the ejection rollers **17** when the sheet sensor **22** detects presence of the recording sheet P (i.e., when the leading edge of the recording sheet P reaches the sheet sensor **22**). Thereafter, when the sheet sensor **22** starts detecting absence of the recording sheet P, in other words, when the sheet sensor **22** does not detect presence of the recording sheet P any more (i.e., when the rear edge of the recording sheet P passes by the sheet sensor **22**), the sheet position detecting unit **55** detects that the recording sheet P is conveyed to a position, in which the recording sheet P starts to be carried by the switchback rollers **20**.

The positional deviation correcting unit **56** corrects amounts of the positional deviation stored in the positional deviation storage unit **54** according to a position of the recording sheet P being conveyed along the sheet-conveying direction. The discharging timing determining unit **57** determines ink discharging timing (moments) to discharge ink from the nozzles **10**, based on the positional deviation amounts corrected by the positional deviation correcting unit **56**.

Subsequently, an explanation will be provided about a process to determine the ink discharging timing to discharge ink from the nozzles **10** in the inkjet printer **1**. In order to determine the ink discharging timing to discharge the ink droplets from the nozzles **10**, the control device **50** executes a flow including steps S**101**, S**102** shown in FIG. **6**A prior to activating the printing operation. Further, during an active printing operation, the control device **50** executes a flow including steps S**201**-S**203** shown in FIG. **6**B.

In S**101**, the control device **50**, more specifically, the recording control unit **51**, manipulates the printing unit **2** to print, a patch T including a plurality of deviation detectable patterns Q on the recording sheet P located in a predetermined reference position along the sheet-conveying direction. More specifically, for instance, the control device **50** controls the printing unit **2** to print a plurality of straight lines L**1**, which extend in parallel with the sheet-conveying direction and are arranged along the head-moving direction, by discharging ink from the nozzles **10** while moving the carriage **11** in one orientation (e.g., rightward) along the head-moving direction. After that, the control device **50** controls the printing unit **2** to print a plurality of straight lines L**2**, which are tilted with respect to the sheet feeding direction and intersect the plurality of straight lines L**1**, respectively, by discharging ink from the nozzles **10** while moving the carriage **11** in the other direction (e.g., leftward) along the head-moving direction. Thereby, as shown in FIG. **7**B, the patch T including the plurality of deviation detectable patterns Q arranged along the head-moving direction is printed. Each positional deviation detecting pattern Q includes a combination of the mutually intersecting straight lines L**1** and L**2**. At this time, ink droplets are discharged from the nozzles **10** in accordance with design-based ink discharging timing that is determined, for example, based on an assumption that the recording sheet P is not in the wave shape but flat. Alternatively, if the positional deviation amounts are adjusted preliminarily in advance, and the ink discharging timing is previously determined preliminarily in accordance with below-mentioned procedures, ink droplets may be discharged from the nozzles **10** in accordance with the preliminarily determined ink discharging timing.

Next, in S**102**, the control device **50**, in particular, the reading control unit **52**, controls the reading unit **5** to read the printed deviation detectable patterns Q, and the control device **50**, in particular, the positional deviation acquiring unit **53**, acquires the positional deviation amounts of ink droplets landing on the top portions Pt and the bottom portions Pb. The acquired positional deviation amounts, i.e., the gap information, are stored in the positional deviation storage unit **54**.

More specifically, for example, when the deviation detectable patterns Q as shown in FIGS. **7**A and **7**B are printed in a situation where there is a deviation between the ink landing position in the rightward movement of the carriage **11** and the ink landing position in the leftward movement of the carriage **11**, the straight line L**1** and the straight line L**2** of each deviation detectable pattern Q are printed to be displaced with respect to each other along the head-moving direction. Therefore, the straight line L**1** and the straight line L**2** intersect each other in a position displaced from centers of the straight lines L**1** and L**2** along the sheet-conveying direction depending on the positional deviation amount with respect to the ink landing positions along the head-moving direction. Further, when the reading unit **5** reads each deviation detectable pattern Q, the reading unit **5** detects a higher degree of brightness at the intersection of the straight lines L**1** and L**2** than the brightness at any other portion of the read deviation detectable pattern Q. Accordingly, by reading each individual deviation detectable pattern Q and acquiring a position with the highest degree of brightness within the read deviation detectable pattern Q, it is possible to detect the position of the intersection of the straight lines L**1** and L**2**.

In the embodiment, the control device **50**, more specifically, the reading control unit **52**, controls the reading unit **5** to read deviation detectable patterns Q, of the plurality of deviation detectable patterns Q, in a section Ta and a section Tb that respectively correspond to each top portion Pt and each bottom portion Pb within the patch T. Further, the control device **50**, more specifically, the positional deviation acquiring unit **53**, acquires the position with the highest degree of brightness within each individual read deviation detectable pattern Q, so as to acquire the positional deviation amounts of ink droplets landing on the plurality of top portions Pt and the plurality of bottom portions Pb. The acquired positional deviation amounts are stored in the positional deviation storage unit **54**.

As described above, in S**102**, the control device **50** controls the reading unit **5** to read only the deviation detectable patterns Q in the sections Ta and the sections Tb. Therefore, in S**101**, the control device **50** may control the printing unit **2** to print at least the deviation detectable patterns Q in the sections Ta and the sections Tb.

Further, when a printing operation is activated, in S**201**, the control device **50**, more specifically, the sheet position detecting unit **55**, detects positions of a leading edge and a rear edge of a recording sheet P being conveyed based on results detected by the sheet sensor **21**.

The positions of the recording sheet P being conveyed during the printing operation will be described with reference to FIGS. **8**A-**8**F. First, as the recording sheet P is conveyed, the recording sheet P is placed in a condition as shown in FIG. **8**A, in which the recording sheet P is nipped by the feed rollers **13** and pressed downward by the corrugated plates **15**. Thereafter, when the leading edge of the recording sheet P reaches the ejection rollers **17**, as shown in FIG. **8**B, the recording sheet P is placed in a condition, in which the recording sheet P is nipped by the ejection rollers **17** in addition to being nipped by the feed rollers **13** and pressed by the corrugated plates **15**.

Further, when the recording sheet P reaches the corrugated spur wheels **18** and **19**, as shown in FIG. **8**C, the recording sheet P is place in a condition, in which the recording sheet P is pressed by the corrugated spur wheels **18** and **19**, in addition to being nipped by the feed rollers **13** and the ejection rollers **17** and being pressed by the corrugated plates **15**. Thereafter, when the leading edge of the recording sheet P reaches the switchback rollers **20**, as shown in FIG. **8**D, the recording sheet P is placed in a condition, in which the recording sheet P is nipped by the switchback rollers **20**, in addition to being nipped by the feed rollers **13** and the ejection rollers **17** and being pressed by the corrugated plates **15** and the corrugated spur wheels **18**, **19**. Furthermore, when the rear edge of the recording sheet P passes through the feed rollers **13**, the recording sheet P is placed in a condition, in which the recording sheet P is released from the feed rollers **13** but is nipped by the ejection rollers **17** and the switchback rollers **20** and pressed by the corrugated plates **15** and the corrugated spur wheels **18**, **19**.

Thereafter, when the rear edge of the recording sheet P passes through the corrugated plates **15**, as shown in FIG. **8**F, the recording sheet P is placed in a condition, in which the recording sheet P is released from the pressure from the corrugated plates **15** but is nipped by the ejection rollers **17** and the switchback rollers **20** and pressed by the corrugated spur wheels **18**, **19**.

It is to be noted that the positions of the leading edge and the rear edge of the recording sheet P change within the positions shown in FIGS. **8**A-**8**F depending on the position of the recording sheet P. In other words, the position of the recording sheet P among the positions shown in **8**A-**8**F can be determined by the positions of the leading edge and the rear edge of the recording sheet P. Therefore, in S**201**, the positions of the leading edge and the rear edge of the recording sheet P are detected in order to determine the position of the recording sheet P along the sheet-conveying direction.

In S**202**, the control device **51**, in particular, the positional deviation correcting unit **56** corrects the amounts of positional deviation of the ink droplets, acquired in S**102** by the positional deviation acquiring unit **53**, in consideration of the positions of the leading edge and the rear edge of the recording sheet P, which are detected in S**201**.

More specifically, while the recording sheet P can be held in the rippled wave shape by the pressure from the corrugated plates **15** and the corrugated spur wheels **18**, **19**, the recording sheet P in the conditions shown in FIGS. **8**A and **8**B is held in the rippled form by the pressure solely from the corrugated plates **15** but is not pressed by the corrugated spur wheels **18**, **19**. Meanwhile, in the conditions shown in FIGS. **8**C-**8**E, the recording sheet P is held in the rippled form by the pressure from both of the corrugated plates **15** and the corrugated spur wheels **18**, **19**. In the condition shown in FIG. **8**F, the recording sheet P is held in the rippled form by the pressure from the corrugated spur wheels **18**, **19** but is not pressed by the corrugated plates **15**.

It is to be noted that the condition to hold the recording sheet P changes depending on the members, by which the recording sheet P is pressed to be in the rippled form, between the corrugated plates **15** and the corrugated spur wheels **18**, **19**. As the condition to hold the recording sheet P changes, amplitude between the tops Pt of the mountain portions Pm and the bottoms Pb of the valley portions Pv and a height (an average level) of the entire recording sheet P change.

Further, while the recording sheet P can be nipped by one or more of the feed rollers **13**, the ejection rollers **17**, and the switchback rollers **20**, when in the condition shown in FIG. **8**A, the recording sheet is nipped solely by the feed rollers **13**. Meanwhile, in the conditions shown in FIGS. **8**B and **8**C, the recording sheet P is nipped by the feed rollers and the ejection rollers **17**. When the recording sheet P is in the condition shown in FIG. **8**D, the recording sheet P is nipped by the feed rollers **13**, the ejection rollers **17**, and the switchback rollers **20**. When the recording sheet P is in the condition shown in FIGS. **8**E and **8**F, the recording sheet P is nipped by the ejection rollers **17** and the switchback rollers **20**.

It is to be noted that the condition to hold the recording sheet P changes depending on the members, by which the recording sheet P is nipped, among the feed rollers **13**, the ejection rollers **17**, and the switchback rollers **20**. As the condition to hold the recording sheet P changes, the amplitude between the tops Pt of the mountain portions Pm and the bottoms Pb of the valley portions Pv and the height (the average level) of the entire recording sheet P change.

More specifically, variation of the amplitudes in the ripples in the recording sheet P and the amounts of the gap between the average level of the entire recording sheet P and the ink discharging surface **12***a* are shown in FIGS. **9**A-**9**E. FIG. **9**A illustrates the condition of the recording sheet P before the leading edge of the recording sheet P reaches the ejection rollers **17** (see FIG. **8**A). FIG. **9**B illustrates the condition of the recording sheet P after the leading edge reached the ejection rollers **17** and before the leading edge reaches the switchback rollers **20** (see FIGS. **8**B, **8**C). FIG. **9**C illustrates the condition of the recording sheet P after the leading edge reached the switchback rollers **20** and before the rear edge passes through the feed rollers **13** (see FIG. **8**D). FIG. **9**D illustrates the condition of the recording sheet P after the rear edge of the recording sheet P passed by the corrugated plates **15** (see FIG. **8**E). FIG. **9**E illustrates the condition of the recording sheet P after the rear edge of the recording sheet P passed by the corrugated plates **15** (see FIG. **8**F).

As seen in FIGS. **9**A-**9**E, the amplitudes (A**1**-A**5**) of the ripples in the recording sheet P becomes greater as the recording sheet P is conveyed farther downstream along the sheet-conveying direction (i.e., A**5**>A**4**>A**3**>A**2**>A**2**). Meanwhile, the amounts of the gap (G**1**-G**5**) between each average height of the recording sheet P and the ink discharging surface **12***a* is the greatest in the condition shown in FIG. **9**D and decreases to be smaller in an order: the condition shown in FIG. **9**B, the condition shown in FIG. **9**A, the condition shown in FIG. **9**C, and the condition shown in FIG. **9**E (G**4**>G**2**>G**1**>G**3**>G**5**).

Thus, the amplitude in the ripples in the recording sheet P and the vertical position of the entire recording sheet P vary depending on the position of the recording sheet P along the sheet-conveying direction. Therefore, if the ink droplets are discharged from the nozzles at constant timings regardless of the positions of the recording sheet P along the sheet-conveying direction, the amounts of positional deviation of the ink droplets landing on the recording sheet P become different depending on the condition of the recording sheet P, which is in one of the conditions shown in FIGS. **8**A-**8**F. Thus, the amounts of positional deviation change as the recording sheet P is being conveyed along the sheet-conveying direction within a printing operation.

Meanwhile, the deviation detectable patterns Q having been printed in S**101** are printed on the recording sheet P, which is in one of the conditions shown in FIGS. **8**A-**8**F. The condition of the recording sheet P, among the conditions shown in FIGS. **8**A-**8**F, depends on a size of the recording sheet P and a range, in which the deviation detectable patterns Q are printed. Therefore, the deviation detectable patterns Q indicate amounts of positional deviation on a recording sheet P, which is located in the same reference position as the recording sheet P being located when the deviation detectable patterns Q were printed on the recording sheet P in S**101**.

Therefore, in S**202**, the control device **50**, more specifically, the positional deviation correcting unit **56**, corrects the amounts of positional deviation acquired in S**102** with respect to the position (more specifically, the positions of the leading edge and the rear edge) of the recording sheet P, which is to be used in the current printing operation, along the sheet-conveying direction. In particular, the positional deviation correcting unit **56** corrects the amounts of positional deviation in consideration of the variation of the amplitude in the ripples in the recording sheet P and the vertical position (height) of the entire recording sheet P.

The amounts of correction in consideration of the amplitude in the ripples in the recording sheet P and the height of the recording sheet P may be acquired, for example, in a following method. That is, when the amount of positional deviation acquired in S**102** is represented by Y, and an amount of positional deviation after being corrected is represented by Y', Y' is obtained by a formula, $Y'=a\cdot Y+b$. In this respect, "a" represents a value, which is set depending on a ratio of amplitude in the ripples in the current recording sheet P with respect to the amplitude in the ripples in the former recording sheet P used in S**101**. Meanwhile, "b" represents a value, which is set depending on a ratio of an amount of the gap between the ink discharging surface **12***a* and the current recording sheet P with respect to the amount of the gap between the ink discharging surface **12***a* and the former recording sheet P used in S**101**.

In S**203**, the control device **50**, more specifically, the discharging timing determining unit **57**, determines the timing to discharge the ink droplets from the nozzles **10** according to the corrected amounts of positional deviation, which is acquired in S**202**. In this respect, it is noted that, in S**102**, the control device **50** acquires only the positional deviation amounts on the top portions Pt and the bottom portions Pb. In the embodiment, the recording sheet P is deformed in the ripples with the top portions Pt and the bottom portions Pb alternately arranged, by the plurality of corrugated plates **15**, the plurality of ribs **16**, and the plurality of corrugated spur wheels **18** and **19**. Therefore, by obtaining the positional deviation amounts on the top portions Pt and the bottom portions Pb, it is possible to estimate positional deviation amounts on portions of the mountain portions Pm other than the top portions Pt and on portions of the valley portions Pv other than the bottom portions Pb. Accordingly, the control device **50** determines the ink discharging timing to discharge ink onto the portions of the mountain portions Pm other than the top portions Pt and onto the portions of the valley portions Pv other than the bottom portions Pb, based on the estimated positional deviation amounts.

It is noted that, in S**102**, the control device **50** may read the deviation detectable patterns Q on the portions of the mountain portions Pm other than the top portions Pt and the portions of the valley portions Pv other than the bottom portions Pb, and may obtain positional deviation amounts from the read deviation detectable patterns Q to determine the ink discharging timing to discharge ink from the nozzles **10**, based on the obtained positional deviation amounts and in consideration of the position of the recording sheet P along the sheet-conveying direction. However, in this case, the quantity of the positional deviation amounts obtained by the positional deviation acquiring unit **53** and stored in the positional deviation storage unit **54** is large, and it requires a large capacity of RAM for the control device **50**.

According to the embodiment described above, when the recording sheet P is deformed in the wave shape with the plurality of mountain portions Pm and the plurality of valley portions Pv alternately arranged along the head-moving direction, amounts of the gap between the ink discharging surface **12***a* and the recording sheet P vary depending on portions (areas) on the recording sheet P. Further, when the amounts of the gap between the ink discharging surface **12***a* and the recording sheet P vary depending on portions (areas) on the recording sheet P, there are differences between the positional deviation amounts caused in the rightward movement of the carriage **11** and the positional deviation amounts caused in the leftward movement of the carriage **11**. Therefore, in order to place ink droplets in appropriate positions on such a wave-shaped recording sheet P, it is required to determine the ink discharge timing to discharge the ink droplets from the nozzles **10** depending on the amount of the gap at each portion on the recording sheet P.

Thus, in the embodiment, by printing the deviation detectable patterns Q on the wave-shaped recording sheet P and reading the printed deviation detectable patterns Q, the control device **50** acquires the amounts of positional deviation on the top portions Pt and the bottom portions Pb.

In this respect, however, the amplitude of the ripples in the recording sheet P and the vertical position of the recording sheet P vary depending on the position of the recording sheet P along the sheet-conveying direction. Therefore, in S**203**, if the control device **50** determines the ink discharging timing to discharge ink from the nozzles **10** in the printing operation based on the amounts of positional deviation acquired in S**102** but regardless of the position of the recording sheet P along the sheet-conveying direction, actual ink-landing positions on the new recording sheet P are displaced from the ink-landing positions of the former recording sheet P, which is used in S**101**. Thus, quality of the printed image may be lowered.

Meanwhile, in the embodiment, when an image is printed on the new recording sheet P in the printing operation, the amounts of the positional deviation acquired from the deviation detectable patterns Q in S**102** are corrected according to the position of the recording sheet P along the sheet-conveying direction. Thus, amounts of positional deviation corrected for the new recording sheet P can be acquired. In other words, preferably corrected amounts of positional deviation for the new recording sheet P in the printing operation can be acquired. Therefore, in S**203**, the ink discharging timing to discharge the ink droplets from the nozzles **10** for the new recording sheet P in the currently-active printing operation can be correctly determined.

Further, in the embodiment described above, the amplitude of the ripples in the recording sheet P and the vertical position of the entire recording sheet P differ depending on the members, by which the recording sheet P is held in the rippled form, between the corrugated plates **15** and the corrugated spur wheels **18**, **19**, and by which the recording sheet P is nipped, among the rollers **13**, **17**, **20**. In the embodiment, therefore, the amounts of positional deviation with respect to the new recording sheet P are corrected in consideration of the position of the recording sheet P along the sheet-conveying direction. Thus, the amounts of positional deviation may be accurately corrected.

Furthermore, in the embodiment described above, the amounts of positional deviation on the new recording sheet P are corrected in consideration of the amplitude of the ripples in the recording sheet P and the vertical position of the entire recording sheet P. Thus, the amounts of positional deviation on the new recording sheet P may be corrected even more accurately.

Hereinabove, the embodiment according to aspects of the present invention has been described. The present invention can be practiced by employing conventional materials, methodology and equipment. Accordingly, the details of such materials, equipment and methodology are not set forth herein in detail. In the previous descriptions, numerous specific details are set forth, such as specific materials, structures, chemicals, processes, etc., in order to provide a thorough understanding of the present invention. However, it should be recognized that the present invention can be practiced without reapportioning to the details specifically set forth. In other instances, well known processing structures have not been described in detail, in order not to unnecessarily obscure the present invention.

Only an exemplary embodiment of the present invention and but a few examples of their versatility are shown and described in the present disclosure. It is to be understood that the present invention is capable of use in various other combinations and environments and is capable of changes or modifications within the scope of the inventive concept as expressed herein. For example, the following modifications are possible. It is noted that, in the following modifications, explanations about the same configurations as exemplified in the aforementioned embodiment will be omitted.

In the aforementioned embodiment, the plurality of ribs **16** in the same height are arranged respectively in the midst positions along the head-moving direction between the adjoining corrugated plates **15**. Accordingly, the amplitude of the ripples formed in the recording sheet P by the ribs **16** and the corrugated plates **15** are constant at the portions corresponding to the ribs **16** along the head-moving direction.

In a first modified example, as shown in FIG. **10**, two ribs **16***a* at the outermost positions along the head-moving direction are formed to be smaller in height than the other ribs **16** on the inner side. The ribs **16***a* on the outermost positions are formed to be shorter at least in a following reason. That is, if the two ribs **16***a* are formed to be higher, the rippled recording sheet P on the ribs **16***a* may tend to be uplifted and float at the outer end ranges of the recording sheet P along the head-moving direction by own rigidity of the recording sheet P. Thus, the mountain portions Pm and the valley portions Pv may not be formed regularly along the head-moving direction. Therefore, in order to prevent the irregularity in the ripples, the ribs **16***a* may be formed to be smaller in the vertical direction to prevent the uplift.

In the above configuration, when the recording sheet P is in one of the conditions shown in FIGS. **8**A-**8**E, the amplitude A**11** at the portions corresponding to the ribs **16***a* is smaller than the amplitude A**12** at the other portions corresponding to the ribs **16**. When the rear edge of the recording sheet P passes by the corrugated plates **15**, in the condition shown in FIG. **8**F, the outer end ranges in the recording sheet P along the head-moving direction do not form the mountain portions Pm or the valley portions Pv but extend flat (see FIG. **11**). Therefore, in the first modified example with the shorter ribs **16***a*, when the recording sheet P is in the condition shown in FIG. **8**F, the ink discharging timing to have the ink droplets land on the outer end ranges in the recording sheet P is not corrected based on the amounts of positional deviation acquired in S**102**. Rather, the ink droplets are discharged to the outer end ranges according to discharging timing, which is set for a recording sheet P being not rippled but flat.

In a second modified example, as shown in FIG. **12**, auxiliary ribs **71** having the same height which is lower than the height of the ribs **16** are formed at the right side of the leftmost rib **16**, at both the left and right sides of each of the second, fourth, fifth, and seventh ribs from the left end in the head-moving direction, and at the left side of the rightmost rib **16**. Among the plurality of auxiliary ribs **71**, an auxiliary rib **71** closer to one of the corrugated plates **15** on an outer side along the head-moving direction is disposed across a longer distance from its accompanying rib **16** than a distance between an auxiliary rib **71** farther from the one of the corrugated plates on the outer side along the head-moving direction and its accompanying rib **16**. Namely, in FIG. **12**, a distance X**1** is longer than a distance X**2**, the distance X**2** is longer than a distance X**3**, and the distance X**3** is longer than a distance X**4** (X**1**>X**2**>X**3**>X**4**).

It is to be noted, in order to deform the recording sheet P in the rippled form, that the recording sheet P is pulled inward from the outer sides toward a central area of the recording sheet P along the head-moving direction to be pressed downward by the corrugated plates **15**. In this respect, it is more difficult to press the recording sheet P downward by the corrugated plates **15** at the central area than the outer areas. If the auxiliary ribs **71** are formed in evenly-spaced arrangement, therefore, due to the pressing difficulty at the central area, the recording sheet P may not be formed in the regular ripples at the central area.

In consideration of the pressing difficulty at the central area, therefore, in the second modified example, the distance between the auxiliary rib **71** and its accompanying rib **16** along the head-moving direction is set to be greater (wider) as the position of the auxiliary rib **71** is closer to the outside along the head-moving direction (i.e., the closer to the outer sides along the head-moving direction the auxiliary rib **16** is, the greater the distance between the auxiliary rib **71** and its accompanying rib **16** along the head-moving direction becomes). With the widely-spaced auxiliary ribs **71**, it is more difficult to press the recording sheet P downward by the corrugated plates **15** in the outer areas in the recording sheet P compared to the central area. In other words, the widely-spaced auxiliary ribs **71** in the outer areas allow the corrugated plates **15** to press the recording sheet P downward more easily at the central area than the outer areas. Thus, easiness of pressing downward is equalized relatively throughout the recording sheet P along the head-moving direction, and the recording sheet P can be deformed into the regular rippled form steadily.

With the unevenly-arranged auxiliary ribs **71**, the auxiliary ribs **71** arranged at the positions closer to the outside along the head-moving direction support the recording sheet P from below at the positions closer to the corrugated plates **15** than the other auxiliary ribs **16** closer to the central area. In this respect, as has been described above, the recording sheet P is more difficult to be pressed downward by the corrugated plates **15** at the outer areas than the central area along the head-moving direction. Therefore, once the recording sheet P is released from the corrugated plates **15**, i.e., in the condition shown in FIG. **8**F, but the recording sheet P continues to be supported by the ribs **16** and the auxiliary ribs **71** from below, the valley portions Pv may not be formed regularly at the outer areas in the recording sheet P along the head-moving direction. In such a case, for example, as shown in FIG. **13**A, a level of the valley portions Pb **1** at the outer areas may be substantially equivalent to the average height of the recording sheet P, and the amplitude of the ripples in the recording sheet P may be reduced in the outer areas. For another example, as shown in FIG. **13**B, a level of the bottoms Pb of the valley portions Pv may be raised to be equivalent to a level of the tops Pt of the mountain portions Pm at the outer areas.

In such cases, when the recording sheet P comes to the position in the condition shown in FIG. **8**F, the ink discharging timing to have the ink droplets land on the outer areas in the recording sheet P may be corrected in S**202** differently from the other areas closer to the central area. In particular, when the recording sheet P is deformed into the irregular rippled form as shown in FIG. **13**A, the amounts of positional deviation for the bottoms Pb at the outer areas may be replaced with amounts of positional deviation for the average height of the recording sheet P. When the recording sheet P is deformed into the irregular rippled form as shown in FIG. **13**B, the amounts of positional deviation for the bottoms Pb at the outer areas may be replaced with amounts of positional deviation for the tops Pt of the mountain portions.

In the embodiment described above, the amounts of positional deviation are corrected in consideration of the members, by which the recording sheet P is held in the rippled form, between the corrugated plates **15** and the corrugated spur wheels **18**, **19**, or by which the recording sheet P is nipped, among the rollers **13**, **17**, **20**. However, the correction may not necessarily be made in consideration of all of these factors.

In the inkjet printer **1**, the inkjet head **12** is arranged in the position between the feed rollers and the ejection rollers **17** along the sheet-conveying direction, Meanwhile, the switchback rollers **20** are arranged in the downstream position with respect to the ejection rollers **17**. In consideration of the positional relation, difference in amplitudes of the ripples in the recording sheet P and difference in vertical positions of the entire recording sheet P to be influenced by the switchback rollers **20** are relatively small compared to the difference in amplitudes of the ripples in the recording sheet P and the vertical positions of the recording sheet P influenced by the feed rollers **13** and the ejection rollers **17**.

Therefore, the amounts of positional deviation may be corrected in consideration of the members, by which the recording sheet P is held in the rippled form, between the corrugated plates **15** and the corrugated spur wheels **18**, **19**, and by which the recording sheet P is nipped, between the rollers **13**, **17**. More specifically, the amounts of positional deviation may be corrected depending on the condition of the recording sheet P, whether the recording sheet P is in the condition shown in FIG. **8**A, the conditions shown in FIGS. **8**B-**8**D, or the conditions shown in FIG. **8**E-**8**F.

In the embodiment described above, the inkjet printer **1** is equipped with the switchback mechanism including the switchback roller **20** in order to enable double-face printing. However, the inkjet printer **1** may not necessarily be equipped with the switchback mechanism if the double-face printing function is not required. When the inkjet printer **1** is not equipped with the switchback mechanism, the amounts of positional deviation may be corrected without considering the nipping effect of the switchback roller **20**.

In the embodiment described above, the recording sheet P is deformed into the rippled form by being pressed by at least one of the corrugated plates **15** and the corrugated spur wheels **18**, **19**. Therefore, an extent of the variation in the amplitudes of the ripples in the recording sheet P caused by being pressed by the corrugated plates **15** and/or the corrugated spur wheels **18**, **19**, is greater than an extent of the variation in the amplitudes of the ripples in the recording sheet P caused by being nipped by the feed rollers **13**, the ejection rollers **17**, and/or the switchback rollers **20**.

Therefore, the amounts of positional deviation may be corrected at least in consideration of the pressing effect from the corrugated plates **15** and/or the corrugated spur wheels **18**, **19**, without considering the nipping effect from the feed rollers **13**, the ejection rollers **17**, and/or the switchback rollers **20**. More specifically, the amounts of positional deviation may be corrected depending on the condition of the recording sheet P, i.e., whether the recording sheet P is in the conditions shown in FIGS. **8**A, **8**B, the conditions shown in FIGS. **8**C-**8**E, or the condition shown in FIG. **8**F.

In the embodiment described above, the recording sheet P is pressed by the corrugated plates **15**, which are arranged on the upstream side with respect to the inkjet head **12** along the sheet-conveying direction, and the corrugated spur wheels **18**, **19**, which are arranged on the downstream side with respect to the inkjet head **12** along the sheet-conveying direction. However, one of the corrugated plates **15** and the corrugated spur wheels **18**, **19** may be omitted.

When one of the corrugated plates **15** and the corrugated spur wheels **18**, **19** is omitted, the recording sheet P is pressed solely by the other one of the corrugated plates **15** and the corrugated spur wheels **18**, **19** at all time while the recording sheet is in the rippled form. Therefore, the amounts of positional deviation may be corrected in consideration of the members, by which the recording sheet P is nipped among the feed rollers **13**, the ejection rollers **17**, and the switchback rollers **20** without considering the pressing effect from the other one of the corrugated plates **15** and the corrugated spur wheels **18**, **19**.

In the embodiment described above, in S**202**, the amounts of positional deviation of the ink droplets landing on the recording sheet P are corrected in consideration of the amplitude of the ripples in the recording sheet P and the vertical position of the entire recording sheet P, which depend on the position of the recording sheet P along the sheet-conveying direction. However, the amounts of positional deviation may not necessarily be corrected in consideration of all of these factors.

For example, the difference in vertical positions of the recording sheet P depending on the position of the recording sheet P along the sheet-conveying direction is relatively small compared to the difference in amplitudes of the ripples in the recording sheet P depending on the position of the recording sheet P along the sheet-conveying direction. Therefore, in S**202**, the amounts of positional deviation of the ink droplets landing on the recording sheet P may be corrected solely in consideration of the variation in the amplitudes of the ripples in the recording sheet P depending on the position of the recording sheet P along the sheet-conveying direction and without considering the variation in vertical positions of the recording sheet P depending on the position of the recording sheet P.

Further, the amounts of positional deviation may be corrected in consideration of other various factors, which may vary depending on the position of the recording sheet P along the sheet-conveying direction and may affect the amounts of the gap between the ink discharging surface **12***a* and each position in the rippled recording sheet P, but other than variations of the amplitudes of the ripples in the recording sheet P or the vertical positions of the entire recording sheet P.

In the aforementioned embodiment, the reading unit **5** of the inkjet printer **1** reads the printed deviation detectable patterns Q so as to acquire the positional deviation amounts on the top portions Pt and the bottom portions Pb. However, the configuration for reading the printed deviation detectable patterns Q to acquire and correct as needed the positional deviation amounts is not limited to the above configuration.

For example, the medium sensor **23** may read the deviation detectable patterns Q printed on the recording sheet P. In this case, when light emitted by the light emitting element of the medium sensor **23** is incident onto the straight lines L**1** and L**2** of a deviation detectable pattern Q, the light is not reflected thereat or received by the light receiving element. Meanwhile, when the light emitted by the light emitting element of the medium sensor **23** is incident onto a portion of the recording sheet P without any straight line L**1** or L**2** printed thereon, the light is reflected thereat and received by the light receiving element. Accordingly, it is possible to recognize presence of the straight lines L**1** and L**2** based on a determination as to whether the light receiving element of the medium sensor **23** receives the light emitted by the light emitting element. Thereby, it is possible to acquire a positional deviation amount from positional information on the intersection of the straight lines L**1** and L**2**.

Alternatively, for instance, in a process for manufacturing the inkjet printer **1**, a device different from the inkjet printer **1** may read the deviation detectable patterns Q printed by the inkjet printer **1** to acquire the positional deviation amounts.

In this case, for instance, the positional deviation amounts acquired or corrected by the device different from the inkjet printer **1** may be written into the positional deviation storage unit **54**, and the positional deviation correcting unit **56** may correct the positional deviation amounts having been written in the positional deviation storage unit **54**. Further, in this case, the inkjet printer **1** may not necessarily be a multifunction peripheral having the reading unit **5**. The inkjet printer **1** may be provided with only a printing function.

In the aforementioned embodiment, the control device **50** controls the reading unit **5** to read the patch T including the plurality of deviation detectable patterns Q so as to acquire the positional deviation amounts. However, for instance, the positional deviation amounts may be acquired by a following alternative method. The method may include printing a plurality of patches T with respective ink discharging timings gradually differing by a predetermined time amount. The method may further include making the user select one of the plurality of patches T that includes a printed deviation detectable pattern Q with the straight lines L**1** and L**2** intersecting each other in a position closest to the center of the straight lines L**1** and L**2** along the sheet conveying direction (i.e., making the user select a patch T that includes a deviation detectable pattern Q printed with the smallest positional deviation amount) in comparison with the other patches T, with respect to each of the top portions Pt and the bottom portions Pb.

In the aforementioned embodiment, the control device **50** controls the printing unit **2** to print the deviation detectable patterns Q, each of which has the straight lines L**1** and L**2** intersecting each other, by discharging ink from the nozzles **10** while moving the carriage **11** rightward along the head-moving direction to print the straight line L**1** and discharging ink from the nozzles **10** while moving the carriage **11** leftward along the head-moving direction to print the straight line L**2**.

However, for instance, the deviation detectable patterns may be printed in a following alternative method. The method may include printing a plurality of straight lines L**2** on a recording sheet P, on which a plurality of lines similar to the straight lines L**1** are formed in advance, by discharging ink from the nozzles **10** while moving the carriage **11** rightward or leftward along the head-moving direction, so as to form deviation detectable patterns, each of which has the ready-formed straight line and a printed straight line L**2** intersecting each other. Even in this case, by reading the formed deviation detectable patterns, it is possible to acquire a positional deviation amount, relative to a reference position, of an ink droplet landing on each of the top portions Pt and the bottom portions Pb.

Further, the deviation detectable pattern is not limited to a pattern with two straight lines intersecting each other. The deviation detectable pattern may be another pattern configured to provide a printed result that varies depending on the positional deviation amount.

In the aforementioned embodiment, the ink discharging timing to discharge ink from the nozzles **10** is determined based on the positional deviation amounts on the top portions Pt and the bottom portions Pb. However, for instance, the ink discharging timing may be determined based on positional deviation values on portions of the mountain portions Pm other than the top portions Pt and portions of the valley portions Pv other than the bottom portions Pb.

In the aforementioned embodiment, by printing the deviation detectable patterns Q and reading the printed deviation detectable patterns Q, the positional deviation amounts on the top portions Pt and the bottom portions Pb are acquired as gap information related to a gap between the ink discharging surface **12***a* and each portion on the recording sheet P. However, different information related to the gap between the ink discharging surface **12***a* and each portion on the recording sheet P may be acquired. Further, the gap between the ink discharging surface **12***a* and each portion on the recording sheet P may be acquired by directly measuring the gap.

What is claimed is:

1. An inkjet printer, comprising:

an inkjet head configured to discharge ink droplets from nozzles formed in an ink discharging surface thereof;

a head scanning unit configured to move the inkjet head with respect to a recording medium to reciprocate along a head-moving direction, the head-moving direction being parallel with the ink discharging surface of the inkjet head;

a conveyer unit configured to convey the recording medium in a conveying direction which intersects with the head-moving direction, the conveyer unit including a feed roller and an ejection roller, which are arranged to have the inkjet head interposed therebetween along the conveying direction;

a position detecting unit configured to detect a position of the recording medium along the conveying direction;

a wave shape generating mechanism configured to deform the recording medium into a predetermined wave shape that has tops of portions protruding toward the ink discharging surface and bottoms of portions recessed toward a side opposite from the ink discharging surface, the tops and the bottoms being alternately arranged along the head-moving direction, the wave shape generating mechanism comprising a first wave shape generating unit, which is disposed on an upstream side with respect to the inkjet head along the conveying direction, and a second wave shape generating unit, which is disposed on a downstream side with respect to the inkjet head along the conveying direction;

a gap information storing device configured to store predetermined reference gap information related to a gap between the ink discharging surface and the recording medium at a predetermined reference position along the conveying direction, the predetermined reference gap information being acquired from a predetermined range in the recording medium; and

a correcting device configured to correct the predetermined reference gap information stored in the gap information storing device according to a condition of the recording medium, which is determined depending on a position of the recording medium along the conveying direction detected by the position detecting unit,

wherein the condition of the recording medium includes a first condition, in which the recording medium is deformed into the wave shape by the first wave shape generating unit, a second condition, in which the recording medium is deformed into the wave shape by the first wave shape generating unit and the second wave shape generating unit, and a third condition, in which the recording medium is deformed into the wave shape by the second wave shape generating unit,

wherein the predetermined reference gap information corresponds to a gap between the ink discharging surface and the recording medium in one of the first, second, and third conditions,

wherein the predetermined reference gap information is maintained without correction when the condition of the recording medium is determined to be the one of the first, second, and third conditions corresponding to the predetermined reference gap information, and

wherein the predetermined reference gap information is corrected when the condition of the recording medium is determined to be one of the other two of the first, second, and third conditions than the one of the first, second, and third conditions corresponding to the predetermined reference gap information.

2. The inkjet printer according to claim **1**,

wherein the correcting device is configured to correct the predetermined reference gap information based on amplitude of the wave shape, the amplitude being variable depending on the position of the recording medium along the conveying direction.

3. The inkjet printer according to claim **2**,

wherein the correcting device is configured to correct the predetermined reference gap information based on a position of the recording medium along a direction orthogonal to the ink discharging surface, the position of the recording medium varying depending on the position of the recording medium along the conveying direction.

4. The inkjet printer according to claim **1**, further comprising:

a discharging timing determining device configured to determine ink discharging timings to discharge ink from the nozzles of the inkjet head, while the inkjet head is moved along the head-moving direction, in accordance with the predetermined reference gap information corrected by the correcting device.

5. The inkjet printer according to claim **1**, further comprising:

a pattern-printing control device configured to control the inkjet head and the head scanning unit to print a plurality of deviation detectable patterns along the head-moving direction on the recording medium, the deviation detectable patterns being used to detect amounts of positional deviation of ink landing positions along the head-moving direction for the ink discharged from the nozzles while the inkjet head is moved along the head-moving direction;

a pattern reading unit configured to read the plurality of deviation detectable patterns printed on the recording medium; and

a positional deviation acquiring device configured to acquire the amounts of positional deviation of the ink landing positions within the predetermined range in the recording medium based on a result read by the pattern reading unit,

wherein the gap information storing device stores the amounts of positional deviation of the ink landing positions to be the predetermined reference gap information, and

wherein the correcting device corrects the amounts of positional deviation of the ink landing positions according to the position of the recording medium along the conveying direction detected by the position detecting unit.

6. The inkjet printer according to claim **1**,

wherein the predetermined reference gap information corresponds to the gap between the ink discharging surface and the recording medium in the second condition, and

wherein the correcting device corrects the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the first and third conditions.

7. The inkjet printer according to claim **1**,

wherein, when the predetermined reference gap information corresponds to the gap between the ink discharging surface and the recording medium in the one of the first, second, and third conditions is represented by Y, the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the other two of the first, second, and third conditions is corrected according to a formula:

$$Y'=a\cdot Y+b,$$

wherein the value a is set depending on a ratio of amplitude in ripples in a wave shape of the recording medium in the one of the first, second, and third conditions with respect to amplitude in ripples in a wave shape of the recording medium in the other two of the first, second, and third conditions, and

wherein the value b is set depending on a ratio of an amount of the gap between the ink discharging surface and the recording medium in the one of the first, second, and third conditions with respect to an amount of the gap between the ink discharging surface and the recording medium in the other two of the first, second, and the third conditions.

8. A method configured to be implemented on a control device connected with an inkjet printer, the inkjet printer comprising:

an inkjet head configured to discharge ink droplets from nozzles formed in an ink discharging surface thereof;

a head scanning unit configured to move the inkjet head with respect to a recording medium to reciprocate along a head-moving direction, the head-moving direction being parallel with the ink discharging surface of the inkjet head;

a conveyer unit configured to convey the recording medium in a conveying direction which intersects with the head-moving direction, the conveyer unit including a feed roller and an ejection roller, which are arranged to have the inkjet head interposed therebetween along the conveying direction;

a position detecting unit configured to detect a position of the recording medium along the conveying direction;

a wave shape generating mechanism configured to deform the recording medium into a predetermined wave shape that has tops of portions protruding toward the ink discharging surface and bottoms of portions recessed toward a side opposite from the ink discharging surface, the tops and the bottoms being alternately arranged along the head-moving direction, the wave shape generating mechanism comprising a first wave shape generating unit, which is disposed on an upstream side with respect to the inkjet head along the conveying direction, and a second wave shape generating unit, which is disposed on a downstream side with respect to the inkjet head along the conveying direction,

the method comprising steps of:

acquiring predetermined reference gap information related to a gap between the ink discharging surface and the recording medium at a predetermined reference position from a predetermined range in the recording medium; and

correcting the acquired predetermined reference gap information according to a condition of the recording medium, which is determined depending on a position of the recording medium along the conveying direction detected by the position detecting unit,

wherein the condition of the recording medium includes a first condition, in which the recording medium is deformed into the wave shape by the first wave shape generating unit, a second condition, in which the recording medium is deformed into the wave shape by the first wave shape generating unit and the second wave shape generating unit, and a third condition, in which the recording medium is deformed into the wave shape by the second wave shape generating unit,

wherein the predetermined reference gap information corresponds to a gap between the ink discharging surface and the recording medium in one of the first, second, and third conditions,

wherein, in the step of correcting, the predetermined reference gap information is maintained without correction when the condition of the recording medium is determined to be the one of the first, second, and third conditions corresponding to the predetermined reference gap information, and

wherein, in the step of correcting, the predetermined reference gap information is corrected when the condition of the recording medium is determined to be one of the other two of the first, second, and third conditions than the one of the first, second, and third conditions corresponding to the predetermined reference gap information.

9. The method according to claim **8**,

wherein the predetermined reference gap information corresponds to the gap between the ink discharging surface and the recording medium in the second condition, and

wherein, in the step of correcting, the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the first and third conditions is corrected.

10. The method according to claim **8**,

wherein, when the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the one of the first, second, and third conditions is represented by Y, in the step of correcting, the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the other two of the first, second, and third conditions is corrected according to a formula:

$$Y'=a\cdot Y+b,$$

wherein the value a is set depending on a ratio of amplitude in ripples in a wave shape of the recording medium in the one of the first, second, and third conditions with respect to amplitude in ripples in a wave shape of the recording medium in the other two of the first, second, and third conditions, and

wherein the value b is set depending on a ratio of an amount of the gap between the ink discharging surface and the recording medium in the one of the first, second, and third conditions with respect to an amount of the gap between the ink discharging surface and the recording medium in the other two of the first, second, and the third conditions.

11. An inkjet printer comprising:

an inkjet head configured to discharge ink droplets from nozzles formed in an ink discharging surface thereof;

a conveyer unit configured to convey a recording medium in a conveying direction, the conveyer unit including a feed roller and an ejection roller, which are arranged to have the inkjet head interposed therebetween along the conveying direction;

a position detecting unit configured to detect a position of the recording medium along the conveying direction;

a wave shape generating mechanism configured to deform the recording medium into a predetermined wave shape that has tops of portions protruding toward the ink discharging surface and bottoms of portions recessed toward a side opposite from the ink discharging surface, the tops and the bottoms being alternately arranged along an orthogonal direction being orthogonal to the conveying direction, the wave shape generating mechanism comprising a first wave shape generating unit, which is disposed on an upstream side with respect to the inkjet head along the conveying direction, and a second wave shape generating unit, which is disposed on a downstream side with respect to the inkjet head along the conveying direction; and

a control device configured to:

store predetermined reference gap information related to a gap between the ink discharging surface and the recording medium at a predetermined reference position along the conveying direction, the predetermined reference gap information being acquired from a predetermined range in the recording medium; and

correct the stored predetermined reference gap information according to a condition of the recording medium, which is determined depending on a position of the recording medium along the conveying direction detected by the position detecting unit,

wherein the condition of the recording medium includes a first condition, in which the recording medium is deformed into the wave shape by the first wave shape generating unit, a second condition, in which the recording medium is deformed into the wave shape by the first wave shape generating unit and the second wave shape generating unit, and a third condition, in which the recording medium is deformed into the wave shape by the second wave shape generating unit,

wherein the predetermined reference gap information corresponds to a gap between the ink discharging surface and the recording medium in one of the first, second, and third conditions,

wherein the predetermined reference gap information is maintained without correction when the condition of the recording medium is determined to be the one of the first, second, and third conditions corresponding to the predetermined reference gap information, and

wherein the predetermined reference gap information is corrected when the condition of the recording medium is determined to be one of the other two of the first, second, and third conditions than the one of the first, second, and third conditions corresponding to the predetermined reference gap information.

12. The inkjet printer according to claim **11**

wherein the control device is further configured to correct the predetermined reference gap information based on variation of amplitude of the wave shape, which varies depending on the position of the recording medium along the conveying direction.

13. The inkjet printer according to claim **12**,

wherein the control device is further configured to correct the predetermined reference gap information based on a position of the recording medium along a direction orthogonal to the ink discharging surface, the position of the recording medium being variable depending on the position of the recording medium along the conveying direction.

14. The inkjet printer according to claim **11**,

wherein the control device is further configured to determine ink discharging timings to discharge ink from the nozzles of the inkjet head in accordance with the corrected predetermined reference gap information.

15. The inkjet printer according to claim **11**,

wherein the control device is further configured to:

control the inkjet head to print a plurality of deviation detectable patterns along the orthogonal direction on the recording medium, the deviation detectable patterns being used to detect amounts of positional deviation of ink landing positions along the orthogonal direction for the ink discharged from the nozzles;

read the plurality of deviation detectable patterns printed on the recording medium;

acquire the amounts of positional deviation of the ink landing positions within the predetermined range in the recording medium based on the read plurality of deviation detectable patterns,

store the amounts of positional deviation of the ink landing positions to be the predetermined reference gap information; and

correct the stored amounts of positional deviation of the ink landing positions according to the detected position of the recording medium along the conveying direction.

16. The inkjet printer according to claim **11**,

wherein the predetermined reference gap information corresponds to the gap between the ink discharging surface and the recording medium in the second condition, and

wherein the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the first and third conditions is corrected.

17. The inkjet printer according to claim **11**,

wherein, when the predetermined reference gap information corresponds to the gap between the ink discharging surface and the recording medium in the one of the first, second, and third conditions is represented by Y, the predetermined reference gap information corresponding to the gap between the ink discharging surface and the recording medium in the other two of the first, second, and third conditions is corrected according to a formula:

$$Y'=a\cdot Y+b,$$

wherein the value a is set depending on a ratio of amplitude in ripples in a wave shape of the recording medium in the one of the first, second, and third conditions with respect to amplitude in ripples in a wave shape of the recording medium in the other two of the first, second, and third conditions, and

wherein the value b is set depending on a ratio of an amount of the gap between the ink discharging surface and the recording medium in the one of the first, second, and third conditions with respect to an amount of the gap between the ink discharging surface and the recording medium in the other two of the first, second, and the third conditions.

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